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SAMPLING AND ANALYSIS PLAN (SAP): REMEDIAL INVESTIGATION/FEASIBILITY STUDY AT THE NORTH RIDGE ESTATES SITE, KLAMATH FALLS, OREGON

VOLUME 1

Prepared by:

D. Wayne Berman, Ph.D.
Aeolus, Inc.

And

Dulcy Berri, RG
PBS Engineering and Environmental

Prepared for:
Melvin Stewart, Mary Lou Stewart, M. L. Stewart, Inc., and Kenneth L. Tuttle, as Trustee of the Kenneth L. Tuttle MD, PC Employees Profit Sharing and Pension Fund for Kenneth L. Tuttle, and Maurice E. Bercot

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Submitted By:

Dulcy Berri
Dulcy A. Berri, RG
PBS Engineering and Environmental
Project Coordinator

July 7, 2005
Date

Reviewed and Approved By:

Alan Goodman
U.S. EPA Region 10
Remedial Project Manager

Date

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Distribution List:

Dulcy Berri, RG	PBS Project Coordinator
Dr. D. Wayne Berman	Aeolus, Inc., QA/QC Coordinator
Jeff Heeren	PBS Field Project Manager
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Cliff Walkey	DEQ Project Manager
Tony Kolk	EMS QA Officer
Keith Hunter	ESL QA Officer

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1. INTRODUCTION

This is a Sampling and Analysis Plan (SAP) for the *Initial* Phase of a Remedial Investigation/Feasibility Study (RI/FS) to be conducted at the North Ridge Estates Site in Klamath Falls, Oregon. Although there is a section of this plan that addresses the *final* phase of the RI/FS and a *general* strategy for the final phase is presented, the detailed design of the final phase is on-hold pending completion of this initial phase.

As previously described (Berman and Berri 2005), the initial phase of the RI (which is described in detail in this document) is intended to provide data needed to support design of the final phase of the RI. In turn, the final phase of the RI will comprise the comprehensive investigation that is needed to support remedial decision making at the North Ridge Estates Site. Detailed design of the final phase of the RI will be developed and provided as a supplement to this document once the prerequisite data become available.

As previously defined (Berman and Berri 2005), the primary objectives of the initial phase of this RI/FS are to:

- evaluate the adequacy of the approach currently employed at the North Ridge Estates Site for assessing asbestos-related risk;
- evaluate the viability of surrogate methods for supplementing characterization of the nature and extent of asbestos contamination;
- confirm that amphibole asbestos is a risk driver at the site;
- obtain a preliminary indication of the distribution of asbestos contamination with depth;
- complete an investigation to search for the presence of chemicals of potential concern (COPC's) other than asbestos; and
- complete an investigation to search for the presence of asbestos at locations beyond the main portion of the site, which are alleged based on interviews with site residents and various other sources[1].

Details of the plans for sample collection and analysis that are designed to achieve each of the above-stated objectives are provided in the Field Sampling Plan below. The designs of these plans are based on application of the Data

[1] Note that, although not identified explicitly as an initial phase task in the Work Plan, this effort has been added to the initial phase tasks in response to discussions with EPA.

Quality Objectives (DQO) process; documentation of the decision logic used to optimize plan designs is also presented. Method documentation and Standard Operating Procedures (SOP's) that concisely define the manner in which samples are to be collected, handled, prepared, and analyzed and the manner in which data is to be generated, managed, stored, and interpreted is also provided below as part of the Quality Assurance Project Plan (QAPP).

An overview of issues and a brief description of the organization of this document are presented in the following subsections of this introduction.

1.1. Overview of Issues

As previously described (Berman and Berri 2005), the big picture concerns at the North Ridge Estates Site relate first to the presence of asbestos from asbestos-containing material (ACM) debris that has been observed in site soils and second to other COPC's (whose alleged presence is based on historical facilities and past practices at the site).

Regarding the first of the above concerns, asbestos is present in site soils both as components of ACM debris and as free asbestos, which is generated by the degradation of ACM. Based on a combination of field observations and knowledge of historical facilities, asbestos contamination may be widespread at the site. However, detailed knowledge of its distribution is lacking, particularly with regard to information about the depth of contamination.

The presence of ACM at shallow depth is of particular interest because, aside from contributing to exposure due to pathways in which sub-surface contamination is directly disturbed, buried ACM may re-surface due to the natural process of freeze-thaw uplift. Thus, ACM debris in the shallow sub-surface may continue to contribute to the reservoirs of both ACM and free asbestos in surface soil and this concern needs to be explicitly addressed.

Although the vast majority of asbestos that has been observed onsite is chrysotile, amphibole asbestos has also been observed. The presence of amphibole asbestos is of particular interest both because, fiber-for-fiber, it is expected to contribute much more substantially to risk (see, for example, Berman and Crump 2001) and because the distribution of amphibole asbestos at the site is expected to vary independently of the overall distribution of chrysotile contamination. Thus, characterization and remediation of amphibole asbestos at the site may require somewhat independent (and additional) efforts to what may otherwise be required for chrysotile.

During a meeting with EPA staff on May 18, 2005, the issues at the North Ridge Estates Site were discussed and the general outline of a strategy for addressing these issues was developed. As was agreed at that meeting:

- remedial decisions at the site would be risk based[2];
- future site use would be assumed to remain residential; and
- due to a combination of timing and a lack of certain information crucial for designing comprehensive characterization at the site, the RI for the site would be phased.

Regarding the second of the above, agreement was also reached at the meeting on the complete set of exposure pathways that need to be addressed to assess residential land use at the North Ridge Estates Site. These are presented in the conceptual site model (Section 4.1.3 of Berman and Berri 2005)[3].

Regarding the last of the above bullets, it was also agreed that this current SAP comprises the detailed design of the initial phase of the RI and that the design for the final phase of the RI will be provided in a supplemental SAP, which will be developed once the data from the initial phase become available.

1.2. Organization of the Document

This SAP contains:

- an FSP for the initial phase of the project (Section 2);
- a QAPP (Section 3);
- a Schedule for laboratory and field activities (Section 4);
- References (Section 5);
- Figures (Section 6); and
- Tables (Section 7).

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[2] During more recent discussions, regulators have indicated a desire to preserve the ability to render exposure-based decisions. Because the additional data required to support "exposure based" decisions can also be collected as part of the final phase of the RI without changing the overall strategy for the site and because the additional data that might be required is unlikely to be excessive, pending further discussion, this requirement may be addressed as part of the final phase of the RI.

[3] Based on more recent discussions, the single omission of a line in the CSM to explicitly represent freeze-thaw uplift will be added when the work plan is finalized.

2. FIELD SAMPLING PLAN

Sampling and analysis designs are presented separately below for each of the six objectives of the initial phase of the proposed RI/FS listed above. The decision logic applied to optimize each design is also presented. The decision logic is developed by applying the DQO process to each objective.

Although the detailed design of the final phase of the RI/FS will not be completed until results from the initial phase become available, a section for documenting this design is included below as a place-holder. The section also presents a discussion of the overall features of the strategy to be applied to comprehensively characterize the site.

2.1. Initial Phase of the Remedial Investigation

Plan designs for addressing the six objectives of the initial phase of the proposed RI/FS are each presented in a separate subsection of this section. The individual plans are then integrated in a final subsection.

2.1.1. Objective 1: Study to Evaluate the Adequacy of the Current Approach for Assessing Asbestos-Related Risks

Following a background discussion describing the approach employed for assessing risks at the North Ridge Estates Site, the decision logic used to optimize the design of a cost-effective study for addressing questions concerning the reliability of the approach are presented. A detailed description of the proposed (optimized) design for the study is then presented in the last subsection of this section.

2.1.1.1. Background

As previously indicated (Berman and Berri 2005), the general approach that has been employed to date for evaluating risks posed by outdoor exposures associated with specific activities at the North Ridge Estates Site is to determine the concentration of asbestos in source materials and to model emissions and dispersion of asbestos from each source to locations where exposure is likely to occur.

The specific approach applied at North Ridge is presented schematically in Figure 1. As can be seen in the figure, for each exposure pathway of interest, a published dust emission model (second column of the figure) is used to estimate dust emissions from each source of interest and this is combined with a simple box dispersion model (fourth column) to generate estimates of dust exposure concentrations (fifth column).

As previously described in detail (Berman 2004), each of the models employed to assess exposure at the North Ridge Estates Site are functions of a defined set of input variables. Some of the variables represent field conditions so that values are derived from field measurements (first column of Figure 1). Depending on the specific model, these may include:

- moisture content, m;
- silt content, s; and
- wind speed, U.

Other variables required for dust emission models represent conditions associated with the specific activities being modeled (third column of Figure 1 with arrows pointing to the emission model). Values for these variables are defined based on the manner in which a particular activity is actually conducted (Berman 2004). Depending on the specific model, these may include:

- the number of wheels[4], w;
- the weight of a vehicle, W;
- the speed of a vehicle, S; and
- the mass handling rate, R_m.

As can be seen in Figure 1, for each exposure pathway of interest, values must also be estimated for the two major input variables of the dispersion model (third column, pointing to dispersion model). These are:

- the cross-wind width of the dispersion box, w_{cp}; and
- the height of the dispersion box, h.

As previously indicated (Berman 2004, 2005), values for these latter two variables are typically estimated based on the dynamics of the specific activities modeled.

As can be seen in the fifth column of Figure 1, dust exposure concentrations (estimated as described above) are then converted to estimates of asbestos exposure concentrations by multiplying them by an asbestos-to-dust ratio factor ($R_{a/d}$). In turn, $R_{a/d}$s are derived for each source from measurements determined using the Modified Elutriator Method (Berman and Kolk 2000).

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[4] At the North Ridge Estates Site, exposures associated with dust generated while walking or running over unpaved surfaces at the site are evaluated using the Copeland Model (USEPA 1985) with the "number of wheels" term (w) modified (adapted) to account for differences in the manner that feet and wheels (respectively) may generate dust when contacting the surface. A detailed description of this adaptation was provided by Berman (2004). Because this adaptation has not been formally validated heretofore, its effects are evaluated explicitly as part of this proposed study.

Four general models have been applied or adapted to address the 10 exposure pathways associated with outdoor, residential activities that have been proposed for consideration at the North Ridge Estates Site. These are: the EPA (Copeland) Model for transport across unpaved surfaces (USEPA 1985), the EPA Model for loading and dumping (USEPA 2002), the EPA Model for agricultural tilling (Cowherd et al, 1974), and a simple model specifically developed to assess exposure associated with the handling of ACM (Berman 2004). Of these:

- the Copeland Model has been applied (with adaptations) to assess exposure associated with walking, running, bicycling, and ATV riding and will also be adapted (in the baseline risk assessment) to assess exposure associated with horseback riding;

- the EPA Model for loading and dumping is applied to assess exposure during child's play in dirt and gardening in dirt; and

- the EPA Model for agricultural tilling is applied to assess exposure during rototilling.

Unlike the other models described above, the model for evaluating exposure associated with the handling of ACM is not a published model but was derived *ab initio* for this project. Therefore the manner in which it will be addressed is different than the manner in which the other models are addressed. Consequently, this model is discussed and addressed separately below (Section 2.1.1.4).

The detailed manner in which published models have been applied at the site (including the manner in which values were determined for each of the input variables for each model) has been previously described (Berman 2004, Berman 2005). However, because questions have arisen about reliability (Berman and Berri 2005), this study is proposed to further evaluate the overall reliability of these models as applied to assess exposure and risk at the North Ridge Estates Site.

Importantly, although the overall accuracy of predictions derived from various models will necessarily be examined, the proposed study is *not* designed to re-validate published dust emission models (except as noted below)[5]. Much

[5] As previously indicated (Berman and Berri 2005), an earlier version of the loading and dumping model that accounts for silt content explicitly (USEPA 2002) will also be evaluated in this study as a potentially superior alternative to the current version of the model, which does not include silt content as an input variable. Also, an earlier version of the moisture content term once incorporated into the Copeland Model (USEPA 1985) may be evaluated in this study as a potentially superior alternative to the version in the current model.

literature has already been devoted to such validation (see the description in Berman 2004). Rather, this study focuses on the adaptations of the models required to apply them at the North Ridge Estates Site, which have not been previously validated. Such adaptations include:

- combining each published emission model with a simple box model (to account for dispersion). This requires adding variables: "w_{cp}" and "h" (respectively representing the cross-wind width of the box and the height of the box into which dust emissions disperse and contribute to exposure);

- multiplying the output dust exposure concentration estimates from each set of emission-dispersion models by a factor representing the ratio of asbestos to dust that is derived for each source based on bulk measurements determined using the Modified Elutriator Method (Berman and Kolk 2000)[6]; and

- specifically for the Copeland Model (used to assess transport over unpaved surfaces), the variable "w" (representing the number of wheels) has been modified when applied to walking and running to account both for differences in the energy of impacts to the ground by feet and wheels (respectively) and differences in the fraction of the transport path during which a foot is in contact with the ground (as opposed to a wheel, which is in continuous contact). Details of these adaptations have been previously described (Berman 2004).

This study is also designed to supplement an earlier study conducted by EPA (see Berman 2005). Thus, the data generated from that earlier study will be incorporated into the current study, as appropriate.

Note, because results will be combined with the earlier study by EPA, which adequately addressed the rototilling model, the rototilling model will not be further addressed here. However, the findings from this study may be applied to the rototilling model as it continues to be applied at the site. Although the loading and dumping model (applied for child's play and gardening) was also evaluated in the EPA study, this latter model is addressed again here due to continuing issues with that model (which may at least partially relate to data limitations in the EPA study, see Berman and Berri 2005).

It should also be noted that, although the overall scope of the proposed study is somewhat limited, it is primarily designed to evaluate the reliability of the general

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[6] Actually, this part of the approach has already been demonstrated, at least as applied to the un-modified Copeland Model (Berman 2000). Moreover, in that study, it was shown that converting dust exposure estimates to asbestos exposure estimates by using the asbestos-to-dust ratio factors generated with the Modified Elutriator Method is generic so that it should be valid when applied to any combination of validated dust emission and dispersion models.

features of an overall approach, rather than the merits of any particular model. Thus, while the proposed study explicitly addresses all four of the general models applied to evaluate exposures associated with outdoor residential activities, the degree with which this general approach is shown to be reliable (or not) can be extrapolated to the rest of the modeling conducted at the North Ridge Estates Site, which has been performed to evaluate other exposure pathways not explicitly addressed here. A complete list of the exposure pathways proposed for consideration at this site is provided in Figure 4 of the draft RI/FS Work Plan (Berman and Berri 2005)[7] with the specific activities to be considered listed in Table 1 of the Work Plan.

One additional consideration is also addressed in the last subsection of this section. Because moisture content plays such a central role in determining emission rates and the goal for supporting risk assessment is to provide long-term estimates of risk, both the adequacy with which moisture content is treated in models and the long-term variability of moisture content at the site need to be addressed. The former of these considerations is addressed along with the consideration of modeling efforts described in the next several sub-sections of this section. To address the latter consideration, a modest sampling effort is proposed to provide monthly measurements of surface and shallow sub-surface moisture contents at the North Ridge Estates Site that is planned to extend over the course of one year. Details of this effort are provided in Section 2.1.1.6.

2.1.1.2. Decision logic for evaluating published models

As previously indicated, the design of the proposed study to evaluate the reliability of the modeling approach used for assessing exposure and risk has been optimized by applying the DQO process. The seven steps of the DQO process are:

1. define the problem;
2. identify the decision(s);
3. identify inputs to each decision;
4. define the boundaries of the study site;

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[7] As previously indicated (Berman and Berri 2005), this approach is also proposed for use to evaluate indoor exposure following track-in and resuspension of asbestos in household dust. Also as previously indicated, however, an additional complication in applying the approach to indoor exposures is that the most appropriate method for determining asbestos loading on exposed, indoor surfaces has not been identified. Such a method must provide results that are suitable for supporting predictions of exposure using a dynamic model of re-suspension. Assuming that one or more vacant houses at the site can be borrowed for conducting an activity-specific monitoring study, a limited study addressing indoor reintrainment of dust is also proposed to supplement the study described here. Due to the more extensive time required to design and implement such a study, however, once the availability of a suitable house is confirmed, this latter study will be proposed either as supplement to this initial phase SAP or as part of the SAP for the final phase of the RI for the North Ridge Estates Site.

5. develop the decision rule;
6. specify limits on decision errors; and
7. optimize the study design.

Each of these steps is applied below to optimize the design of the proposed study.

Define the problem. To evaluate the reliability of the modeling approach being employed to assess exposure and risk at the North Ridge Estates Site, one should first consider the ultimate goal for evaluating exposure and risk. A simple way to represent this is to assume that a target acceptable exposure concentration, C_{trgt}, is defined by working backwards from a target acceptable risk level and that this target is then compared against modeled (predicted) estimates of exposure, C_{pre}, to determine whether cleanup is required.

Typically, the decision rule for comparing predicted exposure concentrations to target levels is setup so that an upper bound estimate of the predicted concentration, $UB(C_{pre})$, is compared to the target value and, if the target is equaled or exceeded, cleanup is concluded to be required. Remembering that C_{pre} is an estimate of the *true* exposure concentration, C_{exp}, (which can never be exactly determined, even if measured), the upper bound estimate is typically defined such that the chance of falsely concluding that the *true* concentration is less than the target is acceptably small. For example, if an *appropriately determined* 95% upper confidence limit, 95%UCL, is applied as $UB(C_{pre})$, than there will never be more than a 5% chance of falsely concluding that a site (or specific source area) is clean. Thus, the null hypothesis, H_o, and alternate hypothesis, H_a, for this situation are:

$$H_o: C_{exp} \geq C_{trgt} \quad (2\text{-}1)$$

$$H_a: C_{exp} < C_{trgt} \quad (2\text{-}2)$$

and choosing among them is determined by comparing $UB(C_{pre})$ to C_{trgt}.

Given the above, questions concerning the reliability of the modeling approach become questions about how to define $UB(C_{pre})$ so that the chance of falsely rejecting the null hypothesis (falsely concluding that cleanup is not required) can be kept acceptably small.

As previously indicated (Section 2.1.1.1), each of the models employed to assess exposure at the North Ridge Estates Site are functions of a defined set of input variables. Some of the variables represent field conditions so that values are derived from field measurements. The contributions by such variables to the overall uncertainty in modeled exposure estimates are a direct and calculatable function of the uncertainty of the measurements employed to derive values for

each variable and the algebraic manner in which each such variable enters into the model. Thus, contributions to UB(C_{pre}) from these variables can be determined formally, at least to the extent that each model accurately captures the algebraic relationship describing the true physical effects of these variables. However (as previously indicated), this proposed study is not intended to re-validate the available dust models. Therefore, other than to consider contributions from these input variables to the overall uncertainty of the models, the effects of these variables will not be further explored here.

Some of the variables represent exposure-related conditions that cannot easily be measured but are estimated based on simple principles. As previously indicated (Section 2.1.1.1), the effects of several of these variables (w, w_{cp}, and h) will be evaluated explicitly in the proposed study.

Define the decisions. The decisions identified in the Work Plan (Berman and Berri 2005) for this objective are re-expressed here in terms of the variables of interest defined above. Thus, the decisions are:

1. whether the C_{pre}'s estimated using this approach are sufficiently accurate (given accurate values for input variables) to predict actual (observed) exposure concentrations, C_{exp}'s, with pre-defined confidence;

2. alternately, whether an algorithm can be developed that generates sufficiently conservative estimates of UB(C_{pre}) to assure that the chance that any particular C_{exp} is underestimated by the corresponding UB(C_{pre}) remains acceptably small; and

3. finally, if problems are observed, whether the source of such problems can be reasonably attributed either to model limitations or measurement limitations.

Inputs to the decisions. The decisions defined above will be evaluated on multiple levels. First, measured *dust* exposure concentrations will be evaluated and compared to predicted concentrations so that values that have been estimated for the input variables: w, w_{cp}, and h can be optimized. To accomplish this reasonably, dust exposure concentrations will be derived from multiple locations (not just the immediate breathing zone of the single individual conducting each activity) to better define variation within the boxes defined for dispersion associated with each model so that appropriate dimensions for the dispersion box can be better fit to the data.

Measured dust exposure concentrations will also be used to compare the performance of multiple versions of various models to identify the specific versions showing superior performance related to the effects of moisture content and silt content.

Next, measured *asbestos* exposure concentrations will be compared to predicted asbestos exposure concentrations in some experiments (once values for the input variables described above have been optimized) to assess the overall accuracy (reliability) of such predictions.

Finally, observed asbestos-to-dust ratios will be derived from paired measurements of asbestos and dust exposure concentrations and compared to the corresponding ratios that are derived using the Modified Elutriator Method. This will serve to distinguish any effects due to model limitations from effects due to limitations of the measurements from the Modified Elutriator Method. Thus, such comparisons will allow evaluation of the reliability of the overall approach, even if the published EPA models on which the approach relies need to be revised.

For each source area over which an activity-based monitoring experiment is to be conducted, sufficient sampling will be conducted to determine the mean and variability in moisture content, silt content, and asbestos content. Although asbestos concentrations will primarily be determined using the Modified Elutriator Method, to support other objectives of this initial phase of the RI/FS (see Sections 1.0 and 2.1.2 below), the asbestos concentrations may also be determined using other methods, including, for example:

- a general polarized light microscopy (PLM)-based method developed for soils (Perkins and Harvey 1993 and Kolk, No Date);
- the PLM-based SOP developed for soils at the Libby, Montana site (to be obtained from the EPA);
- the transmission electron microscopy (TEM)-based SOP developed for soils at the Libby, Montana site (to be obtained from the EPA); and
- (potentially) other, generalized TEM-based methods.

This is so that asbestos concentrations determined using each of these various methods can be compared and contrasted. This may also allow results using each of the methods to be evaluated for their ability to support prediction of airborne exposure concentrations. Note, however, that theory on the manner in which such "absolute" measures[8] of asbestos concentrations should be input into

[8] Although results from such methods are typically reported either as the mass of asbestos or the number of asbestos structures per unit mass of sampled material, it is not clear that these results truly represent absolute concentrations. To be adequately comfortable that one truly liberates 100% of asbestos in a sample, one would need to disaggregate the sample so thoroughly that it becomes impossible to assure that substantial quantities of asbestos are not destroyed in the process. In contrast, the Modified Elutriator Method incorporates a surrogate

the models is ambiguous (see, for example, Berman 2000), so that some type of calibration may also be required. Values for such a calibration would then need to be developed with limited, paired sampling as part of any comprehensive characterization of the site.

A schematic representation of the general design of the proposed study is presented in Figure 1. As depicted in the sixth column of the figure, a controlled set of experiments will be conducted in which dust exposure concentrations and asbestos exposure concentrations are determined by measurement. These will then be compared with corresponding exposure concentrations that are predicted using experiment-specific inputs (in the manner depicted in the first five columns of the figure). The ratios of paired measurements will also be used to determine the asbestos-to-dust ratios (as indicated in the seventh column) and these will be compared to corresponding ratios derived using the Modified Elutriator Method (as indicated in the first column of the figure).

Define the Boundaries of the Study. A small but diverse set of locations will be selected for conducting each of the planned activity-based simulation experiments. The boundaries of the corresponding source areas (which will be disturbed during the experiments) will be strictly defined so that relevant source characteristics can be accurately determined. Moreover, each experiment will be conducted within a defined time-interval during which relevant environmental conditions will be monitored. Finally, the activities themselves will be conducted in a carefully choreographed manner to assure that activity-specific variables can also be accurately and representatively defined.

Develop the Decision Rules. Three procedures need to be defined to address the relevant issues in this section:

1. a procedure for optimizing the variables: w, w_{cp}, and h;

2. a procedure for assessing the variability between predictions and measurements of exposure concentrations (to be separately applied to dust exposure concentrations and asbestos exposure concentrations); and

3. a procedure for assessing the variability between $R_{a/d}$'s respectively derived using the Modified Elutriator Method and by taking the ratio of observed asbestos and dust exposure concentrations.

The pairs of predicted and measured dust concentrations will be used both to optimize the dispersion parameters for each model and then to assess the

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procedure for determining the relative fraction of asbestos liberated during analysis. A more detailed discussion of these considerations is found in Berman and Kolk (2000).

magnitude of the residual variability, which provides an indication of the degree with which measured concentrations may vary from predicted values (given use of optimized values for input variables that are based on measurement of source characteristics). This addresses the first two of the above needed procedures.

Sources of variation between predicted and measured exposure concentrations include, for example, uncertainty in the measurements collected at area sources to define values for input variables, uncertainty in the overall accuracy of the model, and uncertainty in the measurements collected to determine the dust exposure concentrations to which predictions are being compared. Note that the analysis of dust data in this manner facilitates exploration of the general utility of the emission and dispersion models themselves (independent of effects contributed by combining such models with measurements using the Modified Elutriator Method).

Simple linear regression will be employed to find the values of the dispersion variables (actually a single variable representing the product of w_{cp} and h) that bring the slope of the trend line for a plot of predicted versus measured values closest to one. The corresponding variance statistic will be used to assess the degree of agreement between predicted and measured values. The maximum likelihood estimate of the variance is equal to the sum of the squares of the differences between measured and predicted values divided by the number of paired values:

$$V = \Sigma_i(C_{pre} - C_{msr})^2/N \qquad (2\text{-}3)$$

where:

V	is the variance estimate;
C_{msr}	is the measured dust exposure concentration;
N	is the number of prediction-measurement pairs; and
	all other terms have been previously defined.

Alternately, the values for the w, wcp, and h may be optimized using a maximum likelihood procedure (Bickel and Doksum 1977) and assuming that repeated measurements of airborne dust exposure concentrations at any one location are normally distributed.

Before completing the analysis described above, an Analysis of Variance (ANOVA) may be conducted on the available set of paired predictions and measurements to evaluate (among other things) whether between model variation is significantly greater than within model variation. The effects of source location and replicate will also be evaluated. The results of this analysis may then be used to determine whether data derived from different models should be pooled or analyzed separately to assess V.

Although only the dust measurements collected directly from the breathing zone during each experiment will be paired with predictions to assess the degree of agreement, as previously indicated, additional measurements will also be collected from other sampling points in the general vicinity of the exposure zone during these experiments. Concentrations observed with these other sampling points will then be used to assess dispersion based on general physical principles and this will serve as an independent (reality) check on the optimized values determined for the dispersion variables from the regression defined above.

The above-described methodologies may also be applied to pairs of predicted and measured asbestos exposure concentrations to assess the variability among these pairs. In this latter case, however, if a maximum likelihood procedure is applied, counts of the asbestos structures observed when estimating concentrations will be assumed to be Poisson-distributed (rather than assuming that concentrations are normally distributed).

To evaluate the reliability of use of $R_{a/d}$'s to convert dust exposure predictions to asbestos exposure predictions (the third of the issues listed above), values derived using the Modified Elutriator Method will be compared to observed values derived by dividing asbestos exposure concentration measurements by co-located dust exposure concentration measurements. In contrast to comparing predicted and observed asbestos exposure concentrations directly, this approach allows one to evaluate the uncertainty contributed by use of the Modified Elutriator Method that is independent of the uncertainty contributed by emission and dispersion modeling.

The degree of agreement between the paired $R_{a/d}$'s (derived as described above) will be explored using linear regression. In this case the relationship being explored can be expressed as:

$$\alpha + \beta * R_{MEM} = R_{obs} \qquad (2\text{-}4)$$

where:

α is the intercept for the linear relationship;
β is the slope for the linear relationship;
R_{MEM} is the $R_{a/d}$ determined using the Modified Elutriator Method; and
R_{obs} is the $R_{a/d}$ determined as the ratio of observed asbestos to dust exposure concentrations.

Note that it is possible that β in Equation 2-4 may differ substantially from one. If this is found to be the case, it suggests the possibility (among other things) that the size range of particles included in the counts derived using the automated particle counters in the field may not correspond precisely with the PM_{10} fraction

that survive elutriation in the laboratory and thus contribute to the observed mass of respirable dust determined during application of the Modified Elutriator Method. If a significant deviation from a unit slope is observed, this may suggest the need for some type of field calibration. In either case, the observed variability between paired values of R_{MEM} and R_{obs} will provide a good indication of the degree of reliability that can be placed in use of measurements derived using the Modified Elutriator Method to convert predicted dust exposure concentrations to predicted asbestos exposure concentrations.

For comparing agreement between R_{MEM} and R_{obs}, the variance estimate, V, is estimated and evaluated in precisely the same manner as described above for comparisons between predicted and measured dust (or asbestos) exposure concentrations. Thus:

$$V = \Sigma_i(R_{MEM} - R_{obs})^2/N \qquad (2\text{-}5)$$

Where:

all terms have been previously defined.

Alternately, the comparability between these two, independent procedures for generating estimates of the asbestos-to-dust ratios may be evaluated using maximum likelihood procedures while assuming (1) that repeated measurements of airborne dust exposure concentrations at any one location are normally distributed and (2) that counts of asbestos structures observed during an analysis to determine concentration are Poisson Distributed.

Before completing the analysis described above, an Analysis of Variance (ANOVA) may be conducted on the available set of paired values for R_{MEM} and R_{obs} to evaluate (among other things) whether between model variation is significantly greater than within model variation. The effects of source location and replicate will also be evaluated. The results of this analysis will then be used to determine whether data derived from different models should be pooled or analyzed separately to assess V.

Specify Limits on Decision Errors. As previously indicated, when evaluating exposure and risk under the defined formalism, as long as appropriate estimates can be found for $UB(C_{pre})$, the chance of falsely concluding that a site is acceptably clean can be kept to a suitably small, pre-defined value (say, for example, 5%). As described below, the manner in which the decision rules are defined in this formalism means that controlling this particular error is only a function of finding an appropriate algorithm for determining $UB(C_{pre})$ and this is not a function of the size of the proposed study. Rather, the more limited the study, the more that the resulting algorithm for defining the $UB(C_{pre})$'s will be conservative (which may, however, increase the contrasting error rate: the chance of falsely concluding that remediation is required when it is not).

Given the above, rather than setting specific targets for decision error rates and designing the size of the study to achieve the stated targets, the proposed study will be designed based on other constraints (such as time and budget) while, whatever the outcome, an adequately protective procedure for determining $UB(C_{pre})$ will be defined.

Algorithms for determining $UB(C_{pre})$ may be defined either by accounting for the combined uncertainty in C_{pre} for dust and $R_{a/d}$ for asbestos or may be defined by simply accounting for the degree of uncertainty in C_{pre} for asbestos. Both approaches may be considered and the more robust of the two will be recommended.

The variance statistic, determined as defined above, will be used to define acceptable values for $UB(C_{pre})$. At the simplest level, assuming (as is likely) that the differences between measured and predicted values are normally distributed (and this can be formally tested and the data transformed, if necessary), the following can be employed as an estimate of the 95%UCL for predicted values:

$$UB(C_{pre}) = C_{pre} + 1.97*V^{0.5} \qquad (2\text{-}6)$$

However, this version of the upper bound assumes that the variance is known without error and that the optimized values for the dispersion variables are also known without error. To establish estimates of $UB(C_{pre})$ that account for uncertainty in the estimated parameters (w_{cp} and h) and uncertainty in the estimate of the variance, the profile likelihood method (Bickel and Doksum 1977) will be applied. Note that values for the estimated dispersion coefficients and the estimates of the resulting variance are not independent, therefore, some kind of joint distribution will be evaluated.

An alternate and more robust approach may also be applied. This is to construct a distribution for the predicted values using a Monte Carlo Simulation and to set $UB(C_{pre})$ equal to the 95^{th} percentile of that distribution. This latter approach accounts for uncertainty in the estimate of variance and the optimized values for the dispersion variables. It is also appropriate whether or not the distribution of differences between predicted and measured concentrations is normal.

The above-described procedure defines a mechanism for determining upper bounds to predicted values that can be applied to provide confidence that the chance of under-estimating exposure is kept to an acceptably small value. Whether the modeling approach can be considered reliable then depends on the practicality of this procedure. If it turns out that bounds estimated in this manner are substantially larger than bounds estimated using the more traditional approach of entering conservative estimates for each of the input variables and

simply calculating a conservative prediction, than the modeling approach may have somewhat limited utility.

At the same time, the above-described approach should provide for adequate protection of public health, no matter how uncertain the models appear to be. Therefore, the real question of reliability depends on the acceptable magnitude of the probability that contamination in an area is found to be unacceptably high (i.e. depends on the error rate for falsely determining that a site requires remediation). Until the relative costs and magnitudes of the errors associated with alternate approaches are better quantified, a definition for the acceptability of this error rate cannot be developed.

The above described approach can be applied to define algorithms for estimating $UB(C_{pre})$ either for dust or asbestos exposure concentrations. A similar approach may also be employed to define $UB(R_{MEM})$.

If the algorithm for $UB(C_{pre})$ derived based on asbestos exposure concentrations (as opposed to dust exposure concentrations) proves to be the more useful of the two approaches, than the algorithm will be set so that $UB(C_{pre})$ represents the equivalent of a 95% UCL, which will limit the chance of falsely determining that a site is acceptably clean to 5%.

If, however, the $UB(C_{pre})$ derived for dust exposure concentrations proves to be the more useful of the two approaches, than $UB(C_{pre})$ will need also to be multiplied by a factor representing $UB(R_{MEM})$. Consequently, the values to be determined for each of these will be selected so that the combined probability of falsely concluding that a site is clean does not exceed 5%:

$$1 - (1 - P_{Cexp})^*(1 - P_{RMEM}) < 5\% \qquad (2\text{-}7)$$

where:

P_{Cexp} is the probability that $UB(C_{exp})$ exceeds the true value; and
P_{RMEM} is the probability that $UB(R_{MEM})$ exceeds the true value.

This will ultimately have the same effect of defining a combined value that is equivalent to a 95% UCL.

Optimize the Study Design. Given the above and the decision that the magnitude of the study will be constrained by time and budget, details of the proposed design for the study to evaluate the reliability of the modeling approach for assessing exposure and risk is defined in the following section.

2.1.1.3. Optimized study design for evaluating published models

The detailed design of the study proposed for evaluating the application of published models to assess exposure and risk at the North Ridge Estates Site is presented here. The design has been optimized to satisfy the constraints discussed in the last section (Section 2.1.1.2).

Given that the goal of this study is to identify a procedure for adequately bounding predicted exposure concentrations that will then be used to adequately limit decision errors (as opposed to achieving a defined set of error rates on decision errors), the design of the study is set more by practical budget limitations than statistical power considerations. At the same time, any limits on the number of experiments to be conducted (which, in turn, limits the number of data points available for completing the analysis), if anything, will increase the uncertainty introduced into the analysis and this will only serve to force incorporation of more conservative considerations when setting bounds for predicted exposures. Thus, limiting the design of the study (if anything) can be considered to be health protective[9].

Given the above and practical budget considerations, the design features of the proposed study are summarized in Table 1. In Table 1, the first column indicates the specific activity to be simulated in each experiment. The second column indicates the nature of the air samples to be collected (asbestos, dust, or only dust). The third, fourth, and fifth column respectively indicate the number of source areas at which each activity is to be simulated, the number of repetitions to be conducted for each activity at each source area, and the number of analyses of each type to be collected during each repetition. The sixth column indicates the total number of analyses (of each type) to be collected for each activity. For dust, this is simply the product of the number of sites, the number of repetitions per site, and the number of samples per repetition. However, fewer analyses may be conducted for asbestos. Although a minimum of one asbestos analysis will be conducted per repetition, asbestos analyses may not be performed on samples collected at all locations monitored during each repetition.

As previously indicated, one dust sample will be collected during each repetition from each of multiple locations within the general vicinity of the zone of exposure. These will be used primarily to provide a better understanding of the nature of

[9] If based on the dust measurements obtained, which can be rapidly determined, it appears that the variation across runs of specific simulations is producing substantial variation, it may be prudent to consider increasing the number of runs. This would be done to improve (reduce) the degree that the proposed approach might otherwise produce excessively conservative bounds that are otherwise driven mostly by uncontrollable variation in environmental conditions during the simulations rather than by any potential deficiencies in the models themselves.

local dispersion, which will be employed to optimize certain inputs to the model (see Section 2.1.1.1). Once each model is optimized, however, only the single, most appropriate measurement (i.e. from the immediate breathing zone) from each repetition will be employed for comparison with a corresponding prediction. With limited exceptions, correspondingly, asbestos analyses will only be performed on the sample collected from the most appropriate location (i.e. the immediate breathing zone) during each repetition.

The last column of Table 1 indicates the number of modeled predictions to be evaluated for each activity. Because predictions are based on models that average dispersion over a box covering the entire exposure area, only one prediction is developed per repetition of each activity. Thus, the number of predictions (and the corresponding number of prediction-measurement pairs) is equal to the product of the numbers in the corresponding cells of Columns 3 and 4 of the table.

Prior to conducting activities at any particular location, each selected source area will need to be adequately characterized. The effort to be completed to characterize each source area is summarized in Table 2. In Table 2, the first column lists the activities to be simulated. The second column indicates the types of characteristics to be analyzed. The third, fourth, and fifth columns respectively indicate the number of source areas at which each activity is to be simulated, the number of analyses of each type to be conducted in each source area, and the (corresponding) total number of analyses of each type. As indicated in the SOP's for sampling of source material (Section 3.0), analyses for asbestos and silt content will be conducted on composite samples that are constructed by combining component samples collected in an array that reasonably represents the entire source area to be characterized.

Although moisture content samples should not be composited, it is expected that (at any one time) the variation in moisture content will be relatively small, so that characterization based on a relatively small number of grab samples should prove adequate. To assure optimum representation, moisture content samples may also be collected on the same day (immediately before and/or immediately after) a particular simulation is conducted.

Results from the source characterization effort will be used to generate values for the input variables of the emission models that describe the nature of source materials. Measurements derived from a meteorological station that will be set up and run during each experiment will also be used to generate values for the input variables of the emission models that describe exposure conditions.

Importantly, source areas to be selected for conducting the proposed simulations should exhibit conditions that are generally representative of North Ridge Estates. Although it is understood that, for some characteristics (such as

asbestos content) conditions may vary over a wide range, the areas selected should fall somewhere within the general range. Specifically, for asbestos content, areas should be chosen that are expected to contain relatively high concentrations so as to maximize the number of asbestos structures observed in samples during the proposed study. At the same time, to the extent possible, the two source areas to be selected for child's play should exhibit substantially different asbestos content so that the effects of such differences can be adequately assessed. Similarly, the two areas selected for bicycling should exhibit substantially different moisture and silt contents so that the effects of these differences can be adequately assessed.

As the objective of this study is to provide a set of prediction-measurement pairs (to be used to evaluate the reliability of modeling), the number and type of such pairs to be generated are summarized in Table 3. In Table 3, the first column indicates the specific activity to be simulated. The next three columns indicate, respectively, the number of predicted-observed pairs of dust exposure concentrations, predicted-observed pairs of asbestos concentrations, and asbestos-to-dust ratio pairs to be obtained for each activity. The numbers of pairs presented in the table include those contributed by data collected during the earlier activity-based monitoring study conducted by EPA (see Berman 2005).

As can be seen in Table 3, a minimum of five pairs of predicted-observed dust exposure concentrations will be generated for evaluating each model in this study. Especially given the limited variation observed across repeated experiments in the original EPA study (see Berman 2005), this should be an adequate number of data points to support both optimizing input variables (w, w_{cp}, and h) and for assessing variability. Moreover, if it proves appropriate to pool the data across activities (i.e. across models), then a *dust* data set of 17 pairs will be available for this purpose. Similarly, pooling all of the *asbestos* data across models will provide a data set of 13 points for assessing variability among these pairs of predicted and observed values. Finally, pooling all of the data across models (which do not affect these latter measurements in any case) will provide a data set of 18 data points for comparing R_{MEM} to R_{obs}.

Some discussion of quality control considerations is also important to emphasize here, with regard to the design of this proposed study. Because the study is intended to assess variability across multiple measurements so that each experiment will be repeated several times, the number of additional quality control analyses required to supplement this study can be minimized. Moreover, the expected, elevated magnitude of the concentrations that will be observed may also minimize the importance of analyzing blanks. Nevertheless, the requisite QC samples will be collected and stored so that, if problems are implied or corrective actions appear needed, QC samples will be available for analysis to address these considerations.

The approach to QC described above will also be applied to background sampling. During each simulation, a background station will be set up to collect samples suitable for characterizing any upwind asbestos concentrations that might potentially affect the reliability of results from the actual simulations. These samples will only be analyzed, however, if excessive variations across repetitious runs, excessive variations across results from multiple exposure locations, and/or excessive variation in asbestos-to-dust ratios derived from exposure concentrations suggest a problem with background.

Finally, it is emphasized that the actual selection of locations suitable for conducting the proposed activity-based monitoring study will be performed in collaboration with EPA staff. Importantly, especially for bicycling (and other runs to be monitored for dust only), not all runs need necessarily be conducted at the North Ridge Estates site itself. It is more important that sites be selected so that they exhibit satisfactory variation in characteristics of interest. Thus, for example, it may even make sense to conduct one or more simulations in Portland (where, for example, differences in weather conditions should assure a substantial difference in soil moisture content).

Methods and procedures to be used for sample collection, handling, preparation, and analysis both to characterize source locations and to characterize exposure concentrations as part of this proposed study are described in the QAPP (Section 3.2.1.1).

2.1.1.4. Decision logic for evaluating the model for handling ACM

As previously indicated, because no appropriate EPA model exists, an emissions model for evaluating exposure associated with the handling of ACM was developed specifically for the North Ridge Estates Site. The features of this model are described in Table 10 of the Soil Report (Berman 2004). Briefly, the model incorporates a series of empirical factors that respectively indicate the fraction of the ACM handled that is crumbled or abraded during handling, F_{crmb}, and the fraction of the crumbled or abraded material that is reduced to respirable dust size, F_{resp}.

Although estimates of values for the factors: F_{crmb} and F_{resp} are provided in the Soil Report (Berman 2004), as indicated in that report, the values are little more than educated guesses. Therefore, a study is required to provide a better indication of the range of values that may be reasonable for these two factors. Thus a study is proposed here for better characterizing the range of values for these two factors.

Importantly, the dispersion factors required to apply this model at the North Ridge Estates Site are identical to those that relate to conditions associated with child's play. Therefore, the values for the dispersion variables that are optimized for

child's play will also be applied to the ACM handling model and no further, independent, evaluation of these factors are required here.

In this case, the problem is to design a simple study (a bench-top laboratory study is envisioned) during which a small number of ACM samples (representing the range of materials present at the North Ridge Estates Site) will be handled and purposely abraded so that data can be collected to determine values for F_{crmb} and F_{resp}. Conservative values for these factors will then be derived by considering the variability observed among the determined values.

Because this is envisioned as an informal study, the decision to be addressed is also informal. However, the following represents one variation that exhibits the required, "yes-no" format:

> *Whether the current estimates for F_{crmb} and F_{resp} (Berman 2004) represent adequately conservative estimates for any actual values to assure that the chance that exposure is underestimated using the corresponding model remains acceptably small.*

The inputs required to estimate F_{crmb} and F_{resp} during an experiment are the mass of ACM that is crumbled or abraded per unit time and the relative mass fraction of the abraded material that is respirable. The former can be determined simply by measuring the change in mass of the ACM pieces before and after abrading them. Determining the latter may be a bit more complex.

To determine the fraction of the material that is reduced to respirable size (relative to the total mass of material abraded), it will be necessary either to capture 100 % of the respirable material that is generated (so that it can be weighed) or to capture representative samples of the entire size range of the particles generated with separate analysis for determination of the respirable fraction. As a more qualitative but simpler alternative, the settleable material generated during abrasion could be captured and weighed and the difference in mass between the material captured and the material lost to abrasion would then represent an upper bound estimate of the mass that becomes respirable. The ultimate design of the proposed study of this issue will address the most promising of the above.

No formal decision rule is proposed for this study. Informally, the maximum of the values observed for F_{resp} during the entire study will likely be selected as the input value of this variable for the model. In turn, the study will include analysis of a small number of ACM samples expected to pose the greatest threat, which

will include material that is known to be highly friable[10] and/or material that contains substantial quantities of amphibole asbestos.

Similarly, the amount of time required to aggressively abrade a target mass of each of the ACM samples during the study will be evaluated to generate a conservative (maximum) mass of ACM that can reasonably handled and abraded over the course of a handling event. This will then be used as the value for the variable F_{crmb}.

As previously indicated, because this involves a qualitative study, error rates will not be formally addressed. However, by selection of the appropriate samples with the appropriate physical properties and by use of the maximum values for F_{crmb} and F_{resp} that are observed over the course of the study, it is expected that the chance of falsely under-estimating risk for this pathway will be minimized by applying the results of this study.

Regarding selection of samples, it is proposed that such selection will be performed in collaboration with EPA staff.

The proposed, "optimized" design for this study is presented in the following subsection.

2.1.1.5. Optimized study design for evaluating the model for handling ACM

To address the issues identified in the last section, a tentative design for the study to better characterize inputs to the model for handling ACM is proposed below. The details of this design may be modified as the study proceeds to facilitate successful completion. The initial design is proposed as follows:

- with the collaboration of EPA staff, a small number of ACM samples will be selected for analysis. As currently envisioned, two different samples of each of three types will be selected. Candidate materials to be included as samples are: CAB, Mag insulation, and aircell. Ideally, large, intact pieces of each type of material (or at least the first two types) with minimum masses of 300 g will be selected. The mass of each sample will be determined to the nearest 0.05 g;

- samples will be placed (along with a piece of medium sand paper mounted on a block) in a larger, heavy plastic bag and sealed. To facilitate handling, the ACM itself may also be mounted onto some type of

[10] Although CAB and Mag insulation will definitely be included in the study, it is not clear that aircell retains sufficient integrity that it can even be easily handled. Certainly, it does not exhibit sufficient integrity to be abraded in the manner envisioned for the study.

block. Sufficient air will also be sealed in the bag to assure that there is "room to work," although adding so much air that the bag can no longer be easily folded or bunched will be avoided;

- once in the bag, a technician will firmly grip the ACM and sanding block through the bag and will vigorously sand the material until between 30 and 60 grams of fine material is produced. The time required to generate the fines will be recorded;

- after allowing the dust in the bag to settle for several minutes, the bag will be opened and approximately 50 ml of distilled water (asbestos free) will be added. The bag will then be resealed and manipulated so that the fines produced during sanding can be concentrated at the mouth of the bag. The bag will then be opened and the water with fines will transferred quantitatively to a 500 ml graduated cylinder. The sanding block and remaining piece of ACM will then be removed from the bag and each will be thoroughly rinsed so that any adhered fines will be dislodged and transferred quantitatively to the 500 ml cylinder. The bag will then be turned inside-out and additional rinse water will be applied to assure that any adhering fines are quantitatively transferred into the cylinder;

- the remaining piece of ACM previously removed from the bag will be dried and its mass determined to the nearest 0.05 g, which will be subtracted from the original mass to determine the mass of abraded material (fines) that were generated in the bag;

- once transfer is complete, the suspension in the cylinder will be topped off so that the volume can be accurately read, it will be energetically swirled to assure thorough mixing, and it will be immediately divided into two equal halves. The volumes of each split will be recorded to the nearest 0.2 ml[11];

- the size distribution (including the respirable fraction) of the fines will be determined in the first half of the suspension using the wet method (ASTM C 177-04);

- the second half of the suspension will be added to a 250 ml beaker containing approximately 30 g of washed play sand (with the mass previously determined to the nearest 0.05 g). The new suspension will be

[11] Note that an alternate design will also be considered in which, rather than splitting the suspension, it will be sequentially processed: first to determine the mass fraction of respirable material and then recombined to prepare for elutriation. The suspension (or some fraction thereof) may also be evaporated to dryness so that the mass of all of the material may be accurately determined and compared against the mass lost during abrading.

energetically swirled to assure thorough mixing of the fines and the sand. Then it will be left to settle and the water will be evaporated to dryness. Note, if the volume of water is so large as to require excessive time for evaporation, the suspension in the beaker may be filtered prior to evaporation to dryness;

- once dry, the material will be placed in a pre-weighed tumbler of the elutriator and conditioned so that it comes to equilibrium with 50% relative humidity;

- the mass in the tumbler will then be determined to the nearest 0.05 grams; and

- the tumbler will then be placed in the dust generator and tumbled and filters of the resulting, size-selected dust will be generated for dust mass determination and asbestos fiber-number determination using the procedures described in the Modified Elutriator Method (Berman and Kolk 2000)[12].

These procedures will be formally codified in an SOP for this study as soon as discussions with the laboratory proposed for conducting the study (EMS) are completed.

2.1.1.6. Optimized study design for evaluating the variability of moisture content with time

Given the need to extrapolate risk estimates to long-term, the time variation in moisture content at the North Ridge Estates Site represents an important consideration. The following study is proposed to obtain at least a general understanding of the time variation of moisture content of surface and shallow sub-surface soils at the North Ridge Estates Site.

It is proposed that monthly sampling be conducted over the course of one year to collect samples from the North Ridge Estates Site for the determination of moisture content. Sampling is to be conducted either on the same day of each month or at a pre-determined randomly selected day for each month. Ideally, it is important that sampling proceed no matter what the weather conditions at the site, as it is variability largely due to weather that is of interest to determine.

On each day that sampling is to be conducted, it is proposed that samples be collected from four pre-selected locations at the site. At each location a surface

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[12] Although this last procedure is *not* required to determine either F_{crmb} or F_{resp}, there may be independent interest for determining the asbestos content of these samples. Such interest and the corresponding utility of such determinations will be discussed with EPA.

sample is to be collected and a sub-surface sample is to be collected from a depth of 2 ft (or the deepest penetration that can be achieved at the defined location, given the limitations of the procedures proposed for sampling). The specific procedures proposed for sample collection are identical to the procedures proposed for collection of surface and sub-surface moisture content samples in Appendix B.

The locations are selected to assure reasonable representation of the range of conditions and reasonable coverage of the areal extent of the site. The proposed locations, which relate to the coding system employed for Table B-1, Appendix B, are:

Area 5a on MBK G;

Area 16 on (b) (6) ;

Area 21 on MBK C; and

Area 24 on MBK A.

During each event, it is proposed that these same areas be sampled so that samples are collected immediately adjacent to the location that was sampled on the previous occasion.

It is anticipated that the data generated by this sampling event will be utilized in a very qualitative but conservative (in a health protective sense) manner to generate a discount factor for exposure averaged over a year (and, ultimately, a lifetime) relative to the exposures observed (or modeled) when conditions are dry. The precise procedure with which these data will be used for that purpose will be developed in collaboration with EPA staff.

2.1.2. Task 2: Study to Evaluate the Viability of Surrogate Methods for Supplementing Characterization of the Nature and Extent of Asbestos Contamination

Following a background discussion describing the surrogate methods being considered for supplementing characterization, the decision logic used to optimize the design of a cost-effective study for addressing questions concerning the utility of the various methods is presented. A detailed description of the proposed (optimized) design for the study is then presented in the last subsection of this section.

2.1.2.1. Background

The general utility of applying asbestos-to-dust ratios determined from Modified Elutriator Method (Berman and Kolk 2000) measurements to convert predicted dust exposure concentrations to asbestos exposure concentrations has been demonstrated (Berman 2000). However, especially considering the costs associated with achieving the target analytical sensitivities that appear to be required to adequately assess risk at the site (as described below), several alternate methods are proposed for consideration. If they can be shown to be both reliable and adequately sensitive, one or more of these surrogates (which are substantially less expensive than the Modified Elutriator Method) may provide data that is suitable for supplementing (or even replacing) the Modified Elutriator Method.

Evaluation of both the reliability and sensitivity of surrogate methods is considered below. However, the latter first requires that target analytical sensitivities be defined. Thus, target analytical sensitivities required to adequately characterize the site are defined in the following subsection. This is followed by a section describing the candidate, surrogate methods proposed for evaluation and a section describing the options for evaluating the reliability and sensitivity of such candidates.

2.1.2.1.1. Defining appropriate target analytical sensitivities

Based on the modeling approach applied at the site to date (Berman 2004, 2005) and extrapolating soil concentrations to risk levels that might be considered acceptable by various regulators, the range of target analytical sensitivities that potentially need to be achieved to adequately assess risk at the site are summarized in Table 4.

In Table 4, the first column indicates the types of structures considered (i.e. protocol structures or 7402 structures) and the second column indicates the type of asbestos (i.e. chrysotile or amphibole). The next three columns indicate the asbestos concentrations in soil potentially capable of generating the level of risk indicated at the top of the column for each of three target risk levels, respectively. These soil concentrations are estimated by:

- converting target risk levels to equivalent airborne concentrations of structures using either the exposure-response factors from the Berman and Crump (2001) protocol or the EPA unit risk factor (IRIS 1988) for protocol structures and 7402 structures, respectively, and assuming the duration and frequency of exposure applicable to the most critical, residential exposure pathway (i.e. child's play) previously addressed at the site (Berman 2004, 2005); and

- back-calculating the equivalent soil concentration for each respective airborne concentration using the optimized model for child's play (Berman 2005).

As can be seen in Table 4, for chrysotile, as long as target risk levels are set no lower than $1x10^{-5}$, target soil concentrations are no smaller than $2x10^{6}$ s/g_{PM10}. Since this value is the target analytical sensitivity commonly adopted when running the Modified Elutriator Method, other than potential cost, there should be no problem using this method to assess chrysotile-related risk at the site. However, for a target risk of $1x10^{-6}$, equivalent soil concentrations for chrysotile are potentially as small as $2x10^{5}$ s/g_{PM10} (when risks are evaluated for 7402 structures using the EPA approach) or $4x10^{5}$ s/g^{PM10} (when risks are evaluated for protocol structures using the Berman and Crump protocol). In the latter case, setting a target analytical sensitivity at such a concentration is potentially achievable for the method, but at increased costs (i.e. by counting an increased number of grid openings). That is why this value is bolded in the table. However, the target analytical sensitivity for 7402 structures is not even reasonably achievable without radically altering the method. That is why this value is bolded and highlighted in the table.

The situation is even more extreme for amphibole asbestos, at least for risks estimated using the Berman and Crump protocol[13]. As can be seen in Table 4, the analytical sensitivity required to analyze for amphibole asbestos that is equivalent to a target level of risk of $1x10^{-4}$ can be achieved using the Modified Elutriator Method, but at somewhat increased cost compared to routine analyses using this method. However, it is not even possible to achieve an analytical sensitivity that is sufficient to evaluate concentrations equivalent to target risks as low (or lower than) $1x10^{-5}$.

Importantly, the above evaluation assumes that risk decisions may be made on data sets containing as few as one sample. If risk decisions are to be based on pooled data from multiple samples, lower effective analytical sensitivities can be achieved for the pooled data. Obviously, however, this increases the cost as the number of analyses required to characterize a particular area must be increased.

Importantly, despite the problems suggested above, experience indicates that the Modified Elutriator Method is among the most sensitive of analytical methods defined to date for determination of asbestos concentrations in soil. This is certainly true for methods that are also capable of providing measurements suitable for supporting prediction of exposure (and risk). Thus, use of surrogates

[13] As can be seen in the table, concentrations equivalent to the indicated, target risk are not different for chrysotile or amphibole asbestos, when risks are evaluated for 7402 structures using the current EPA approach. This is because the current EPA approach does not distinguish between the relative potencies of chrysotile and amphibole asbestos.

is unlikely to improve this situation. Nevertheless, the sensitivity of surrogate methods is considered in the following section.

2.1.2.1.2. Candidate, surrogate methods

Some of the alternatives proposed for consideration are intended more as screening procedures than quantitative methods. As previously indicated (Berman and Berri 2005), these include:

- using the known locations of historical buildings and burial areas and using other visual cues as markers for areas of the site requiring further investigation and, potentially, remediation;

- using a formalized procedure for visually inspecting areas to estimate the ACM content of surface soil as a marker for general asbestos contamination and, potentially, remediation; and/or

- using field determined estimates of the mass fraction of ACM in soil as a marker for general asbestos contamination and, potentially, remediation.

The degree to which evidence of surface contamination with ACM can serve as a marker for deeper contamination and/or the degree that deeper contamination with ACM can serve as a marker of free asbestos contamination in shallower soils (absent evidence of ACM in the shallower soils) may also be evaluated.

Such screening procedures can potentially be used to limit and focus areas of the site where more detailed characterization may be required to support remedial decisions. This will be especially true to the extent that they can be correlated with results from formal analytical methods.

Other surrogates to be evaluated in this section are the formal analytical methods previously identified (Section 2.1.1.2):

- a PLM-based method adapted for analysis of soils;

- the PLM-based method developed for soils at the Libby, Montana site;

- TEM analysis of soil samples prepared using the SOP developed at the Libby, Montana site; and/or

- The Modified Elutriator Method (or other TEM methods) with altered counting rules focusing on shorter, more plentiful asbestos structures to serve as surrogates for the presence of the longer, risk-related structures.

The references for documentation of these methods were identified in Section 2.1.1.2. Other options may also be considered as they are identified.

2.1.2.1.3. Evaluating the reliability and sensitivity of surrogate methods

So that results from the formal analytical methods can be used to support the kinds of risk-based decisions that are being applied at the site, the relationships between concentrations determined using these methods and airborne exposure concentrations attendant to the release of asbestos from sampled sources need to be established. This can potentially be accomplished in a variety of ways:

- to the extent that analytical results determined using one or more of these alternate methods can be shown to reliably correlate with analytical results using the Modified Elutriator Method, they can supplement Modified Elutriator Method measurements to extend characterization over larger areas of the site. Unless the correlation is shown to have a unit slope, however, some type of calibration (adjustment factor) will need to be applied to the data derived using the other methods. Moreover, to the extent that specific decisions are to be based solely on measurements derived using these other methods, the variation observed within the correlation against the Modified Elutriator Method will need to be factored into the algorithm employed for establishing upper bound estimates of exposure: the $UB(C_{pre})$ (see Section 2.1.1.2);

- alternately, if these other methods can be shown to reasonably correlate with the Modified Elutriator Method and can be shown to have equal or greater overall sensitivity to the detection of asbestos, they can simply be used qualitatively to mark boundaries for areas already found to require remediation using the Modified Elutriator Method;

- it may also be possible to establish a direct relationship between measurements determined using these alternate methods and exposure concentrations that are generated when source areas characterized using these other methods are disturbed. However, substantial work may be required to establish the reliability of such relationships, especially given that such relationships will necessarily be empirical and have not previously been evaluated. The theory on how measurements derived using these alternate methods can be related directly to exposure is not entirely clear (see Berman 2000 and Berman and Kolk 2000). To illustrate, if the modeling approach is to be used, for example, there is no unambiguous procedure for inputting measurements determined using these various methods into the published models, as the dimensional units cannot be matched without incorporating several, additional assumptions. This has been addressed in greater detail in Berman 2000. Nevertheless,

as previously indicated, by characterizing source materials in areas selected for conducting the activity-specific monitoring proposed in Section 2.1.1.3 using a variety of candidate methods (in addition to the Modified Elutriator Method), at least an initial indication of any relationship that may exist between measurements determined using these alternate methods and airborne exposure concentrations will be identified.

2.1.2.2. Decision logic

As previously indicated, the design of the proposed study to evaluate the viability of candidate methods for supplementing field characterization has been optimized by applying the DQO process. The decision logic developed to optimize this study is presented below.

Two separate kinds of problems are identified above, which each need to be addressed here. First, there is a need to evaluate the reliability of procedures involving either visual cues or qualitative or quantitative determination the ACM mass fraction as an indicator of overall asbestos contamination. These may serve as screening procedures at the site. Second, the reliability of formal analytical methods (other than the Modified Elutriator Method) for their ability to support prediction of exposure needs to be addressed along with their overall sensitivity. These are considered separately below.

2.1.2.2.1. The reliability of visual cues and ACM content.

In this case, the problem is to evaluate whether knowledge of historical facilities and activities or whether qualitative or quantitative determination of the mass fraction of ACM in soil can serve as adequate markers for the general presence of asbestos contamination at the site (or at least over selected portions of the site under specific conditions). Such cues may prove useful by bounding contamination in either of two ways:

- either suggestions based on historical information or the detection of ACM (at a mass exceeding some, pre-defined minimum value) indicates with high confidence that unacceptable asbestos contamination exists at the indicated location[14]; or

[14] Clearly, if sufficient ACM is present in site soil at a concentration exceeding some (to be defined) critical value, then the presence of ACM itself represents an unacceptable contribution to long-term risk as the ACM will eventually degrade and liberate the asbestos contained within. The issue to be addressed here is whether the presence of ACM (at some concentration) also serves as a reliable marker for the presence of unacceptable concentrations of free asbestos in the surrounding soil. This is important because it suggests a distinction between the adequacy of remediation by simple removal of the ACM itself versus the additional need to address the surrounding soil (in which case, removing the ACM itself constitutes a superfluous action). It should also be noted that the reliability of ACM as a marker may differ for surface and sub-surface soils, due to the history of surficial removals at the site.

- the lack of suggestions based on historical information or (separately) the lack of detection of ACM (at a mass exceeding some, pre-defined minimum) indicates with high confidence that unacceptable asbestos contamination is absent at the indicated location.

In the first case, one or more of these indicators could reliably serve as a positive screen, which would limit the need for detailed characterization to locations where such cues are absent. Where such cues are present, the need for remediation would simply be assumed. In the second case, one or more of these indicators could reliably serve as a negative screen, which would limit the need for detailed characterization to locations where such cues are present. In this case, lack of detection using the screen would provide adequate evidence that unacceptable asbestos contamination does not exist in that location. Clearly, if any of these cues satisfy both of the above (however unlikely), that would be even more useful.

To evaluate the utility of such screening procedures, the decisions to be addressed are:

- *whether the presence (or absence) of free asbestos in soils (exceeding a concentration that could contribute unacceptably to risk[15]) is consistently predicted (with high confidence) by one or more of the markers being evaluated here.*

Inputs to the above decisions are measurements of the combined concentrations of free asbestos and ACM in soil samples from areas of the site selected to represent a broad range of conditions typically encountered at the site along with a corresponding set of values for visual cues and qualitatively and quantitatively determined ACM mass contents for the same set of locations from which the soil samples are ultimately collected.

Because the objective in this case is to "validate" one or more procedures as screening tools, the decision rules to be applied are simple bounding statements. Thus, each of the following rules will be separately applied to each of the candidate screening tools to evaluate their utility either as positive or negative screens:

- *over the range of site conditions evaluated, one or more of the screening procedures consistently (over some pre-defined fraction of samples,*

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[15] In places where ACM is present, contributions from the ACM itself (assuming complete degradation) would also be factored into this decision so that long-term risks are adequately addressed.

possibly 95% or higher) predicts the presence of unacceptable, combined concentrations of ACM and free-asbestos in site soil; or

- *over the range of site conditions evaluated, one or more of the screening procedures consistently (over some pre-defined fraction of samples, possibly 95% or higher) predicts the absence of unacceptable, combined concentrations of ACM and free-asbestos in site soil.*

In each of the above cases, the screening procedure is meant to adequately control for one of the two possible types of errors while completely ignoring consideration of the other; this is typical for screening procedures. To illustrate for the first of the above decision rules, if any of the candidate screening procedures adequately passes the first rule, it would presumably be used to identify areas where cleanup can be considered required without any further characterization. Thus, more detailed characterization would only be required in areas where the screen is negative or ambiguous. Under such circumstances, the screening procedure is assumed to adequately control for the chance of falsely finding a site to be contaminated.

In contrast, if any of the candidate screening procedures adequately passes the second of the above-stated rules, it would be used to identify areas that can be considered to be clean without any further characterization. Thus, more detailed characterization would only be required in areas where the screen is positive. Under such circumstances, the screening procedure is assumed to adequately control for the chance of falsely finding a site to be clean. Clearly applying the screen in this way is much more critical because, when it fails, potentially risky situations may be falsely left in place.

Given the above, the optimum design of a study to evaluate the candidate screening procedures defined here is to select a certain minimum number (currently proposed to be approximately 30[16], but the final number will be determined in collaboration with EPA. The opportunistically selected site

[16] At each location, both a surface and a sub-surface sample are to be collected for a total of approximately 60 samples (not counting QC samples). It is important to note that neither the number of sampling locations nor the number of samples proposed in this case are based on statistical power. That is because the decisions in this case involve the need to feel comfortable that the range of conditions at the site are adequately sampled. This differs from cases for which power curves are typically applied (as, for example, when one is controlling for error in the comparison between an estimate of a mean concentration and a target value). Thus, the number of requisite samples in this case is more a function of the number of unique conditions that need to be included in the evaluation than any estimate of statistical power. That is why we propose to define the ultimate number of samples in collaboration with EPA. At the same time, as is seen in later sections, the data set proposed for collection here will be used for multiple purposes, which should increase the relative value of the samples (even though the sample set is rather large).

locations in this case will be chosen (based on current knowledge or field reconnaissance) to represent a broad range of conditions commonly encountered at the site. A proposed set of such locations, along with the procedures proposed for collecting and analyzing such samples (including an appropriate set of QC samples) are defined in the set of SOPs for this task, which are presented in Section 3.4.1.2.

2.1.2.2.2. The reliability of alternate analytical methods to support prediction of exposure.

The problem in this case is to evaluate whether bulk asbestos measurements derived using analytical methods that are candidates for supplementing general characterization of the North Ridge Estates Site either correlate adequately with measurements derived using the Modified Elutriator Method or can be shown in their own right to adequately predict airborne exposure. The set of methods to be considered has been previously identified (Section 2.1.1.2). It also needs to be determined whether any of the candidate surrogates can achieve adequate sensitivity at reasonable cost (especially for amphibole asbestos) to allow reasonable use.

Given the above, each of the following two decisions may be separately applied to each candidate method:

- whether paired measurements derived using a particular candidate method and the Modified Elutriator Method correlate adequately (especially at the low end of the range of concentrations of interest) to reliably use the candidate method as a substitute for Modified Elutriator Method measurements (at least on a site-specific basis and with or without the need for calibration); or

- whether measurements derived using a particular candidate method can be shown to reliably predict airborne exposure (at least under definable conditions) for some or all of the exposure pathways being considered at the North Ridge Estates Site[17].

Regarding inputs to the latter of these decisions, the simplest approach for evaluating the above decisions for each of the candidate methods will be to "piggy-back" on the study proposed for evaluating the adequacy of the approach used for risk assessment at the North Ridge Estates Site (in Section 2.1.1). This

[17] Importantly, it is beyond the scope of the proposed study to validate use of any particular candidate method as a reliable predictor of exposure. Unlike the Modified Elutriator Method, neither general theory nor any type of prior study currently exists that shows a viable, direct link. Therefore, at best, it may be possible to provide an indication that a direct link exists, which may be further explored in some future, expanded study (which should not be restricted to the North Ridge Estates Site alone).

can be accomplished by simply collecting sufficient masses of bulk material for all samples to be analyzed for characterization of source material under that study such that each such sample can be split and analyzed by any selected surrogate methods of interest (in addition to the Modified Elutriator Method).

Inputs to the first of the above decisions will also include re-analyses of the samples to be collected to characterize source materials in the study designed to evaluate risk procedures (Section 2.1.1). Moreover, to the extent that there is a desire to better quantify any relationship that is suggested by this limited data set, it may be supplemented by expanding the data set to include a selected set of samples from the study proposed to evaluate screening procedures (Section 2.1.2.2.1). The utility of expanding the data set to better quantify correlations (potentially to allow surrogate methods to be used for more than qualitatively supplementing the Modified Elutriator Method) will be discussed with EPA staff who will participate in any decisions regarding the set of samples to be employed for the expanded evaluation.

The boundaries for this proposed study will correspond precisely to the boundaries defined for the study defined in Section 2.1.1.2.

The appropriate decision rule for the first of the above-listed decisions corresponds concisely to that described in Section 2.1.1.2 for comparing paired values of R_{MEM} and R_{obs}, including:

- the potential utility of conducting an initial ANOVA;
- the need for considering deviations from unit slope, which may imply the need for calibration; and
- procedures for establishing contributions to error rates and controlling for such contributions.

In this case, however, what is being compared are paired measurements of bulk asbestos concentrations respectively derived using one of the surrogate analytical methods and the Modified Elutriator Method. Each surrogate analytical method will be evaluated separately.

In addition to the above, the sensitivity of each surrogate (relative to the Modified Elutriator Method) will need to be evaluated and this can be accomplished simply by comparing the range of concentrations over which asbestos is detected by one method but not the other (and visa versa).

The appropriate decision rule of the second of the above-listed decisions corresponds concisely to the decision rule defined in Section 2.1.1.2 for comparing C_{pre} and C_{msr} for asbestos except, in this case, C_{pre} will be derived

based on results from a candidate method (rather than the Modified Elutriator Method) and an algebraic expression representing whatever theory is developed to link these measurements with exposure. Candidate theories will be developed and proposed to the EPA and will be finalized pending discussions with the EPA. Because such theories do not affect the design of the proposed study, deferring specification of such theories to a later date will in no way affect the implementability of this SAP.

SOPs to be applied for sample collection, preparation and analysis in support of this proposed study are provided in the QAPP (Section 3.4.1.2).

2.1.2.3. Optimized sampling plan design

As previously indicated (see above), the proposed study to address supplemental methods has two parts. In the first part (as indicated in Section 2.1.2.2.1), a set of approximately 30 locations will be selected opportunistically at the site to represent a broad range of conditions typically encountered at the site. At each such location, a surface and sub-surface sample will then be collected and analyzed for determination of asbestos content. In addition, each selected location will also be characterized by each of the candidate screening procedures to provide a set of paired observations and measurements that can be used to assess the reliability of each screening procedure. A tentative list of sampling locations for collection of samples to support this effort is provided in Table B-1 of Appendix B. Details of the procedures to be employed for applying each candidate screening procedure and for collecting and analyzing each sample are defined in a series of SOPs presented in the QAPP, Section 3.4.1.2.

In the second part of this study (as indicated in Section 2.1.2.2.2), samples to be collected as part of the study described in Section 2.1.1.3 will be analyzed using each of the candidate methods of interest (in addition to the Modified Elutriator Method) and this will provide the set of paired measurements that will facilitate evaluation of the reliability (and sensitivity) of each of the surrogate methods for use in supplementing site characterization. Details of the methods and procedures to be used for collecting, handling, preparing and analyzing each sample are described in the QAPP (Section 3.4.1.2.2). In this case, procedures for sample preparation and analyses are defined in the methods referenced in Section 2.1.2.1. The samples to be collected and the manner of their collection are then referenced in the QAPP.

2.1.3. Task 3: Study to Confirm Amphibole Asbestos as a Risk Driver

As has been indicated, both chrysotile asbestos and amphibole asbestos have been observed at the site as ACM and as free asbestos structures in soils. Moreover, the concentrations and frequency with which chryostile asbestos has been observed suggests that it may represent a concern requiring remediation in

at least some areas (depending on the target level of risk defined as acceptable at the site).

The situation with amphibole asbestos is somewhat more complicated. Only a relatively small number of amphibole asbestos structures have been observed to date at the North Ridge Estates Site; they constitute about 3% of the total number of asbestos structures observed. Nevertheless, at least when the Berman and Crump (2001) protocol is applied to assess risk, the amphibole asbestos structures that may be present are found to dominate risk concerns. At the same time, the distributions of chrysotile and amphibole asbestos at the site are expected to be largely independent. Therefore, to support risk management decisions, concern for amphibole as a risk driver must be addressed independent of chrysotile.

Because risk-management should be based on robust data and because procedures for addressing amphibole asbestos may differ from those required for addressing chrysotile, a limited and focused study is warranted to better determine whether amphibole asbestos is indeed sufficiently ubiquitous at sufficient concentrations to actually contribute as a risk driver at the site (Berman and Berri 2005).

With regard to the need to obtain at least an initial (low resolution) understanding of the occurrence of amphibole asbestos, we should consider the need to compare and contrast characterization costs vs. remediation costs. If it proves cost-effective, it is always appropriate to assume the worst, forego further characterization, and simply remediate. However, if it is likely that sufficient effort can be saved during remediation to more than offset any corresponding costs for the characterization required to better focus and limit remediation, than characterization is worthwhile.

Differences in the potential balance between characterization and remediation costs are striking when an analyte is particularly hazardous but rare (vs. plentiful). If the analyte is rare, than extensive characterization may be worthwhile as it will mean the difference between remediating an entire (large) site and remediating a few, small, isolated areas. If, however, the analyte is plentiful, than extensive characterization may not be worthwhile because it will only facilitate elimination of a few, small areas while remediation will still be required for the majority of the site. Given that we still do not know in which category amphibole asbestos falls, an initial evaluation of the occurrence of amphibole is justified[18].

[18] Importantly, as agreed at the May 18th meeting, the decision for the need for this effort was to be placed in proper historical context.

2.1.3.1. Decision logic

The problem is that current estimates of amphibole asbestos prevalence at the site are based on conservative extrapolation from data that are largely non-detect. Therefore, a better understanding of the actual prevalence of amphibole asbestos at the site would facilitate planning both for later, more comprehensive characterization and for prioritizing and evaluating remedial options. The corresponding decision to be addressed may be stated as follows:

- *Does the prevalence of amphibole asbestos at the North Ridge Estates Site warrant consideration as a primary risk driver at the site?*

Note that, given the relative magnitudes of the dose-response factor for amphibole asbestos and the sensitivities of the analyses conducted heretofore, simple detection of a single structure of amphibole asbestos in a sample promotes amphibole asbestos as a primary risk driver. Therefore, it is the prevalence of amosite around the site that needs to be evaluated at this point (rather than the actual concentrations). Further, given the limited detection to date, analyses need to be conducted with increased sensitivity to better ascertain whether amphibole asbestos is indeed present.

Inputs to the above decision are results from the analysis of soil at selected locations around the site with the analyses conducted at increased sensitivity to improve the chance of detecting amphibole asbestos, if it is present.

The decision rule for this decision is to conclude that amphibole asbestos represents a general and substantial risk driver at the site, if it is observed at more than one or two isolated locations at the site. The design of any later plan for site characterization would thus need to address amphibole asbestos as a primary concern and decisions concerning both remediation and the extent of future characterization would need to carefully reflect its likely frequency of occurrence.

Regarding control of decision errors, these are addressed only qualitatively for this issue. By conducting asbestos analyses at increased sensitivity, the chance of missing amphibole asbestos in the various samples (if it is present at potentially hazardous concentrations) is limited. Control of the chance of falsely concluding that amphibole asbestos is a hazard warranting concern will be left to the analysis of a later, more comprehensive characterization that may be conducted at the site, if warranted.

Given the above considerations, an optimized plan for confirming amphibole asbestos as a risk driver at the site is presented in the following section.

2.1.3.2. Optimized sampling plan design[19]

As previously indicated (Berman and Berri 2005), the best option for developing data to support improved determination of the occurrence of amphibole asbestos at the site is to re-analyze a selected set of existing samples at improved sensitivity. Such a data set needs to represent large areas of the site and there are two existing sample sets that satisfy this requirement: the set of composite samples collected by PBS in late 2003 to represent average conditions across the site as a whole and the set of composite samples collected by EPA in early 2004 to represent conservative estimates of exposure potentially experienced by residents of specific, individual properties (parcels) at the site (Berman 2004).

Based on the results of analyses already completed on the PBS and EPA sample sets, the samples exhibit largely comparable contaminant concentrations (see Berman 2004) so that they are also likely to provide comparable information regarding the extent of amphibole asbestos contamination should either set be re-analyzed at improved sensitivity. Nevertheless, the EPA sample set is proposed for re-analysis because this data set presents the additional advantage of representing conservative estimates of parcel-specific exposure conditions at the site. Selection of this set also provides the opportunity for completing analysis of all of the samples in this set (including those not previously analyzed).

Note that it is also proposed that this latter sample set be supplemented with the three samples collected to characterize source areas over which the EPA conducted their activity-based monitoring study last year (see Berman 2005). Amphibole asbestos has already been observed in two of these three samples, so that these samples will serve as a positive control.

Regarding the increase in sensitivity that is achievable for these samples, there is a practical limitation in the ability to do this from previously prepared samples. That is, with the five grid specimens previously prepared, only a maximum of approximately 400 grid openings can be assured with reasonable confidence to exhibit sufficient integrity to be included in a scan for analysis. This translates to an improvement in overall sensitivity by about a factor of three, to $5x10^5$ structures/g_{PM10}. Nevertheless, this constitutes enough of an increase in sensitivity to facilitate obtaining a substantially improved understanding of the overall presence of amphibole asbestos. It is therefore proposed that the EPA sample set be analyzed for this study.

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[19] Importantly, the work proposed in this section was designed to preserve historical context, as agreed in the meeting of May 18, 2005. However, modifications may have been added to reflect new realities at the site.

Procedures adopted for acquisition of samples, homogenizing and splitting samples in preparation for analysis, and the modified stopping rules adopted to achieve the improved analytical sensitivity are defined in the QAPP (Section 3.0).

2.1.4. Task 4: Study to Obtain a Preliminary Indication of the Distribution of Asbestos Contamination with Depth[20]

With the exception of limited areas where material is known to have been buried (some of which have been investigated), no information currently exists suggesting the general depth of asbestos contamination at the North Ridge Estates Site. Because even a preliminary understanding of the depth of contamination would facilitate planning both for potential site remediation and for any comprehensive investigation of the site (Berman and Berri 2005), it was determined to be useful to conduct a limited and focused investigation to indicate the general depth of contamination around the site. Among other things, understanding the depth of the reservoir of contamination from which re-surfacing has been occurring (due to freeze-thaw) would also be helpful for refining the conceptual model that has been developed for the site. Thus, the shallow sub-surface (shallow than approximately 2 ft) is of particular interest.

Importantly, the objective proposed here is to obtain an *initial* understanding of the general depth of contamination at the site. It is ***NOT*** intended as a comprehensive determination of the depth of contamination, which will instead be an appropriate focus of the final phase of the RI. However, planning to efficiently design an investigation suitable for supporting the final phase of the RI will be facilitated substantially by the preliminary information to be obtained from the work proposed here.

2.1.4.1. Decision logic

The problem is to design a limited and focused field study to collect data capable of providing a preliminary indication of the general depth of contamination around the site. Given that remedial options may vary substantially, should contamination extend to approximately 2 ft in depth (Berman and Berri 2005)[21], the decision to be supported by this investigation is: whether asbestos

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[20] Importantly, the work proposed in this section was designed to preserve historical context, as agreed in the meeting of May 18, 2005. Thus, for example, the study is designed to extend to 2 ft, rather than to 3 ft, which may be more appropriate given more recent discussions. Nevertheless, the data that would be generated by this study is still extremely useful. Modifications may have been added to reflect new realities at the site.

[21] Although the dividing line at 2 ft was chosen historically and a more detailed division of the subsurface (as described in Section 2.2) will ultimately be needed to distinguish among remedial options, the work proposed here will greatly facilitate design of any comprehensive characterization to address the overall objectives of this RI/FS, which will be addressed by the final phase of the RI..

contamination in various areas of the North Ridge Estates Site extends to depths exceeding two feet over *large* areas of the site.

Note that, more generally, the data to be collected in support of the above decision may also be used to establish a general estimate of the depth to which asbestos contamination extends at those locations where contamination extends no deeper than 2 ft. Again, this is only for large areas of the site; it is certainly possible (and even likely) that asbestos contamination extends to substantially greater depths at least in some isolated areas. Such areas will be addressed as part of the comprehensive characterization of the site to be proposed for the final phase of the RI.

Inputs to the decision would be results from analyses of samples (and/or visual observations) collected from depths of up to 2 ft, which would be used to determine whether asbestos contamination extends to such a depth. In fact, options may exist for obtaining information useful for supporting the above-defined decision. For example, the presence of contamination in samples collected from depth may be determined either by visual inspection for observation of ACM (a qualitative approach) or by laboratory analysis of such soil samples for quantitative determination of the concentrations of asbestos. Some combination of visual observation and formal analysis may be best suited for establishing the overall depth of contamination.

Importantly, because this is a preliminary investigation and there are no plans to obtain information deeper than 2 ft, it is expected that excavations/drilling can be advanced with hand tools (i.e. without the use of a drilling rig). Therefore, at some sampling locations, refusal (due to the encountering of construction debris, rock or well-compacted soil) may prevent advance of sampling to the target depth.

The areal boundaries of this study coincide with the areal extent of the North Ridge Estates Site within which the presence of asbestos contamination is of concern. The depth interval of interest extends from the surface to approximately 2 ft. Of primary interest for this investigation are areas of the site where re-surfacing of ACM has been observed. Therefore, locations from which information about the depth of contamination may be of interest can be selected purposely based on visual inspection of surface conditions.

The decision rule for such an investigation would be that contamination would be considered to extend to a 2 ft depth if:

- natural, undisturbed material is *not* encountered at depths shallower than the target depth of two ft; and

- asbestos contamination is detected (either by visual observation of ACM or by formal analysis for the determination of asbestos) in soil at the maximum depth at which a sample can be reasonably extracted, given the proposed use of hand tools for excavation/drilling.

Regarding the control of decision errors, the primary objective for this proposed investigation will be to limit the chance of missing contamination at depth. Controlling for the chance of falsely concluding that contamination is present at depth will be left to the design of a later, more comprehensive investigation to follow.

Given the above, an optimized plan for investigating the general depth of contamination is presented in the following subsection.

2.1.4.2. Optimized sampling plan design

Based on the decision logic presented in the last section, the best approach for obtaining information useful for providing a preliminary indication of the general depth of asbestos contamination at the site is to:

- select locations for sampling opportunistically, based on a combination of surface cues (to indicate where material is resurfacing) and knowledge from historical information (to indicate where material is most likely to have been deposited historically);

- use a post-hole digger to advance a hole to a depth of 2-ft;

- make observations indicating the nature of the material encountered as the hole is advanced. Especially if obstructions prevent reaching the target depth, record information indicating the type of obstructions (rock, debris, natural hard pan, etc.) that is preventing advance of the hole; and

- collect samples for analysis to determine the asbestos content of the subsurface soil.

Given the above objectives, the set of approximately 30 sampling locations already discussed in Sections 2.1.2.2.1 and 3.1.4.2 (to support evaluation of screening procedures) may represent the best set of locations from which to collect samples for this study. Given that such samples are already proposed for collection for a separate purpose, use of these samples also promotes efficiency.

Specific locations from which these samples are to be collected along with the procedures to be employed to collect, prepare, handle and analyze these samples are described in the QAPP (Section 3.1.4.2).

2.1.5. Task 5: Study to Search for the Presence of COPC's Other than Asbestos

As previously indicated (Berman and Berri 2005), the historical presence of certain facilities and apparent historical activities on parts of the site suggest the possibility that COPC's other than asbestos may be present at the site. Therefore, there is a need to investigate specific portions of the site to confirm or refute the possible presence of these other COPC's.

2.1.5.1. Decision logic

The problem here is to design a limited and focused field study to collect data capable of supporting determination of a decision: whether COPC's other than asbestos are present at the site such that they warrant further study and consideration. The decision would be applied separately to each potential source area and each specific COPC.

Inputs to the decision would be analyses of samples collected at each potential source area for determination of each of the COPC's that is potentially present in each particular source area.

The boundaries of this proposed study will need to be defined following an exhaustive analysis of historical information to identify all areas of the site at which COPC's other than asbestos may have been introduced along with a complete list of the set of COPC's associated with each such area.

The decision rule for such an investigation would be that each particular COPC would be considered to be present and require further consideration in each source area in which it is simply detected. Moreover, this assumes that samples are analyzed using methods capable of detecting each COPC over the full range of concentrations at which they would be considered to be of concern.

Regarding control of decision errors, the primary objective for this proposed investigation will be to limit the chance of missing COPC's that may be present. Controlling the chance of falsely having to address a particular COPC will be left to the design of a later, more comprehensive investigation that might follow the initial detection of a particular COPC.

Given the above, the design of the sampling plan will be optimized by sampling within each source area at which the presence of one or more COPC's is suggested by historical information. Further, such sampling will be conducted opportunistically at locations where (based on historical information) the concentrations of each COPC (if present) are likely to be highest. Samples collected from each particular source area will be analyzed for the complete suite of COPC's whose presence is suggested in that particular source area.

2.1.5.2. Optimized sampling plan design

A complete list of specific source areas that need to be investigated as part of the search for COPC's will be compiled once the acquisition and evaluation of historical information is completed. It is not possible to complete such a list at this time. Further, the specific locations to be sampled within each source area to be investigated will also be identified following completion of the evaluation of historical information.

The set of analytical methods and sampling SOP's required to support the search for COPC's (other than asbestos) is incorporated into the proposed QAPP (Section 3.4.1.5). It was developed based on the candidate set of COPC's previously identified (Berman and Berri 2005).

Note that this particular task of the initial phase of the RI may extend in time into the final phase, which will be initiated as soon as it can be designed based on findings of the other tasks of the initial phase of the RI. Because any additional actions that may be required based on this particular task are largely independent of the asbestos-related work, there is no need to delay initiation of the final phase of the RI while work under this task is completed.

2.1.6. Task 6: Study to investigate locations outside the primary area of the site where additional asbestos contamination is alleged

The possibility that certain historical activities may have spread asbestos contamination beyond the main portion of the site needs to be investigated.

2.1.6.1. Decision logic

The problem here is to design a limited and focused field study to collect data capable of supporting determination of a decision: whether asbestos contamination is present at various locations beyond the main portion of the site at sufficient concentrations to warrant further study and consideration. The decision would be applied separately to each potential source area that is identified.

Inputs to the decision would be analyses of samples collected at each potential source area for determination of asbestos and/or visual evidence of the presence of ACM.

The boundaries of this proposed study will need to be defined following an exhaustive analysis of historical information to identify all areas near the site at which asbestos may have been introduced.

The decision rule for such an investigation would be that asbestos would be considered to be present and require further consideration in each source area in which it is simply detected. Moreover, this assumes that samples are analyzed using methods capable of detecting asbestos over the full range of concentrations at which they would be considered to be of concern.

Regarding control of decision errors, the primary objective for this proposed investigation will be to limit the chance of missing asbestos that may be present. Controlling the chance of falsely having to address asbestos at a particular location will be left to the design of a later, more comprehensive investigation that might follow the initial detection of asbestos at any particular location.

Given the above, the design of the sampling plan will be optimized by sampling within each source area at which the presence of asbestos (beyond the main portion of the site where asbestos is already known to exist) is suggested by historical information. Further, such sampling will be conducted opportunistically at locations where (based on historical information) the concentrations of asbestos at each such location likely to be highest.

2.1.6.2. Optimized sampling plan design

A complete list of specific source areas that need to be investigated as part of the search for asbestos will be compiled once the acquisition and evaluation of historical information is completed. It is not possible to complete such a list at this time. Further, the specific locations to be sampled within each source area to be investigated will also be identified following completion of the evaluation of historical information.

Note that this particular task of the initial phase of the RI may extend in time into the final phase, which will be initiated as soon as it can be designed based on findings of the other tasks of the initial phase of the RI. Because any additional actions that may be required based on this particular task are largely independent of the asbestos-related work over the main portion of the site, there is no need to delay initiation of the final phase of the RI while work under this task is completed.

2.1.7. Integrated Design for the Initial Phase of the Remedial Investigation

For efficiency, the degree that overlapping sample sets can be used to address each of the five study objectives considered above will be exploited. Thus, for example, the same set of sub-surface samples to be collected to evaluate the utility of screening procedures (Section 2.1.2.3) will be employed to evaluate the depth of asbestos contamination (Section 2.1.4.2). Also, the same soil samples collected to characterize source areas over which activity-based sampling will be conducted to evaluate procedures for conducting risk assessments (Section

2.1.1.3) will be analyzed using multiple analytical methods to evaluate their utility for supplementing overall site characterization (Section 2.1.2.3).

2.2. Final Phase of the Remedial Investigation

This section represents a place-holder that generically describes the logic and design plans for the study to complete detailed characterization of the site with respect to asbestos. However, a brief discussion highlighting the main points of a general strategy for the final, comprehensive characterization of the site is provided. This section will be revised and/or completed pending the findings of the initial phase of the proposed RI, including incorporating other COPCs if identified in the initial phase.

2.2.1. General Strategy for the Final Phase of the RI

Asbestos exists at the Site in the forms of both ACM and free asbestos. It is found in surface soils, mixed into deeper soils, and at burial/disposal sites. As previously indicated (Berman and Berri 2005), the pathways by which asbestos in soil potentially contributes to exposure differs as a function of depth. Moreover, the relative effectiveness and viability of various remedial options also differs as a function of the depth of contamination.

Based on the information previously discussed in the CSM for the North Ridge Estates Site (Berman and Berri 2005):

- surface soils (defined here as the top inch of soil) contribute distinctly to pathways involving disturbance during transport over the soil surface;
- between this surface layer and an approximate depth of 2 ft, lies a layer from which ACM is potentially subject to uplift by freeze-thaw. Thus, ACM in this second layer can potentially serve as a continuous reservoir of asbestos that replenishes the surface;
- the entire depth interval from the surface to a depth of approximately 3 ft is defined by ODEQ as the interval in which residential activities may potentially disturb contamination; and
- below a depth of 3 ft, deeper contamination can potentially be disturbed by commercial excavation and construction activities.

Because the cost and implementability of certain remedial options increases as the depth of contamination increases and that the potential impact on future residents decreases with increasing depth (at least

beyond a depth of approximately 3 ft), the above-listed distinctions suggest that whatever comprehensive characterization effort is designed in the final phase of the RI for the North Ridge Estates Site, it should address distinctions in the various soil layers defined above. Thus, the strategy for the final phase of the RI will focus distinctly on each of the layers defined.

Separately, for each of the depth intervals of interest, the density of sampling (i.e. the number of samples) will be determined as a combination of the size of the areas/volumes over which individual decisions will be required and a power function that will address the specific decision rule for each layer.

Typically, such a rule will involve comparison between some conservative estimate of a mean concentration (within each defined area or volume of interest) and a target acceptable concentration. Such rules tend to be readily amenable to construction of an appropriate family of power curves from which the tradeoffs between the cost of characterization and the control of error rates can be evaluated to determine the optimum design for the study.

The findings of the initial phase of the RI (as proposed in this SAP) will also be applied during design of the final phase to facilitate:

- refining the approach for risk assessment to define appropriate, target acceptable asbestos concentrations in soil;
- designing efficient sampling schemes that may incorporate use of multiple methods (e.g. use of one method to determine the need for remediation in a particular source area coupled with use of other, less expensive methods to define the corresponding boundaries of each such source area);
- facilitating determination of the best tradeoff between characterization and making conservative assumptions about remediation for amphibole asbestos;
- facilitating efficient design for characterizing asbestos contamination in the deeper soil intervals of interest;
- focusing characterization efforts required to evaluate any COPC's other than asbestos that are confirmed to be present at the site; and

- focusing characterization efforts required to evaluate source areas beyond the main portion of the site at which asbestos contamination is also confirmed to be a concern.

The following are place-holders for the final phase of the RI:

2.2.2. Source Areas of Interest

2.2.3. Generic Residential Area Source Investigation Design
2.2.3.1. Purpose
2.2.3.2. Questions and their associated decision rules
2.2.3.3. Optimized sampling plan design

2.2.4. Generic Disposal Area Source Investigation Design
2.2.4.1. Purpose
2.2.4.2. Questions and their associated decision rules
2.2.4.3. Optimized sampling plan design

3. QUALITY ASSURANCE PROJECT PLAN

3.1. Introduction and Background

This is a QAPP for the initial phase of an RI/FS to be conducted at the North Ridge Estates Site in Klamath Falls, Oregon. As previously indicated (Section 1), the objectives of the initial phase of the study are to:

- evaluate the adequacy of the approach currently employed at the North Ridge Estates Site for assessing asbestos-related risk;
- evaluate the viability of candidate methods for supplementing characterization of the nature and extent of asbestos contamination;
- confirm that amphibole asbestos is a risk driver at the site;
- obtain a preliminary indication of the distribution of asbestos contamination with depth;
- complete an investigation to search for the presence of COPC's other than asbestos; and
- complete an investigation to search for the presence of asbestos contamination at locations beyond the main portion of the site where asbestos contamination is already known to exist.

To facilitate evaluation in this document, following are brief summaries describing:

- The terminology used to describe asbestos;
- The health effects attributed to asbestos exposure;
- The toxicology of asbestos; and
- Methods used for the determination of asbestos.

3.1.1 Terminology used to describe asbestos

Rather than representing a single chemical species, the term "asbestos" refers to a particular fibrous form (crystalline habit) of a family of hydrated metal silicate minerals. The term asbestos is most commonly applied to the fibrous habits of six of these minerals (IARC 1977). The most abundant type of asbestos is chrysotile, which is the fibrous habit of the mineral serpentine. The other five minerals commonly termed asbestos are all amphiboles (i.e. all partially hydrolyzed, magnesium silicates). These are: fibrous reibeckite (crocidolite), fibrous grunerite (amosite), anthophyllite asbestos, tremolite asbestos, and actinolite asbestos.[22] Importantly, other amphibole minerals (and, potentially, minerals in other classes) also occur in fibrous habits that exhibit the characteristics of asbestos so that they too represent a health concern.

3.1.2 The health effects attributed to asbestos exposure

Exposure to all forms of asbestos has been linked to several adverse health effects, including primarily asbestosis, lung cancer, and mesothelioma (USEPA 1986). Asbestosis, a chronic, degenerative lung disease has been documented among asbestos workers from a wide variety of industries. The lung cancers typically associated with asbestos exposure are generally similar to those described in association with smoking and the effects of asbestos and cigarette smoke have been shown to be synergistic. Mesothelioma, a rare cancer of the connective tissue that lines the pleural cavity (containing the heart and lungs) and the peritoneal cavity (i.e. the gut), has been associated almost exclusively with exposure to fibrous substances including, primarily, asbestos.

The asbestos-related health effects addressed in this study focus primarily on the asbestos-induced cancers: lung cancer and mesothelioma. Because asbestosis generally occurs only at the higher concentrations typical of occupational

[22] While unique names have been assigned to the asbestiform varieties of serpentine (chrysotile) and two of the five amphibole minerals (noted parenthetically above) to distinguish them from their more common, massive forms, such nomenclature has not been developed for anthophyllite, tremolite, or actinolite. Hence the addition of the term "asbestos" to these mineral names to denote the fibrous habit.

exposures, while it is environmental exposures that are of primary interest here, asbestosis is not further addressed.

3.1.3 The toxicology of asbestos

Two independent protocols will each be used in this RI to assess risk:

- the approach currently employed by EPA (IRIS 1988) in which the carcinogenic risk attributable to asbestos is estimated as the product of a slope factor (0.23 cm^3/str) and an exposure concentration (in str/cm^3) where the exposure concentration is determined in terms of "phase contrast microscopy equivalent" (PCME) structures. PCME structures are asbestos structures longer than 5-μ:m with an aspect (length-to-width) ratio greater than 3. Due to limitations in the instrumentation traditionally used to assess such structures (see, for example, NIOSH 7400), PCME structures are also defined as those thicker than 0.25-μ:m; and

- an approach proposed in a protocol by Berman and Crump (2001)[23] in which the carcinogenic risk attributable to asbestos is estimated as the product of an *appropriate* dose-response factor and an exposure concentration where the exposure concentration is determined in terms of "protocol structures". Protocol structures are asbestos structures longer than 5-μ:m and thinner than 0.5-μ:m with structures longer than 10-μ:m separately enumerated. The appropriate dose-response factor to apply to a particular exposure concentration is a function both of the fraction of protocol structures longer than 10-μ:m and the type of asbestos (i.e. chrysotile or amphibole asbestos).

3.1.4 Analytical methods used for the determination of asbestos

When air samples are analyzed for the determination of asbestos (see, for example, ISO 1995 or NIOSH 1989), results are reported in terms of the number of structures (of a selected range of sizes) per unit volume of air. As long as an appropriate range of asbestos structure sizes are selected

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[23] The approach proposed in Berman and Crump (2001) is proposed for use here to assure consistency with the work previously completed at the site. However, if EPA considers it important, risks may also be estimated using a third approach, which is the approach defined in Berman and Crump 2003. This latter approach is a slight refinement of the 2001 protocol in which only protocol structures longer than 10 :m are enumerated to assess risk. Although small, systematic differences (on the order of a factor of 3) exist between risks estimated using each of the two protocols, respectively, relative risks estimated for different exposure pathways or for different areas of the site are expected to remain closely proportional across either procedure. Moreover, should EPA desire that the 2003 protocol be applied, the counting rules in the SOP's developed for this study will need to be modified slightly to optimize the efficiency of counting only protocol structures longer than 10 :m.

for determination, such structure number concentrations are generally considered to predict risk (see, for example, Berman and Crump 2001 or IRIS 1988). In contrast to most other hazardous materials, mass concentrations of asbestos (e.g. the number of grams of asbestos per unit volume of air) have been shown to predict neither structure number concentrations nor any associated risk (Berman and Crump 2001).

Asbestos has traditionally been determined in bulk materials (primarily ACM), using a method (Perkins and Harvey 1993) that relies (at least initially) on polarized light microscopy (PLM) and that, even when confirmed by TEM, results are reported in terms of a mass concentration of asbestos (the number of grams of asbestos per unit mass of soil). However, as indicated above (and as stated in the method itself), such measurements cannot be used to predict risk. In further confirmation, a study by Berman (2000) demonstrated that PLM-based measurements of asbestos concentrations in an asbestos-containing road surface could not be related to airborne asbestos exposure concentrations (generated from vehicular traffic on the road) in any non-arbitrary fashion.

Given the above, as previously indicated, asbestos concentrations are primarily determined in soils in this proposed study using the modified elutriator method (Berman and Kolk 2000), which was shown to provide measurements that can be used to predict exposure and the attendant risk (Berman 2000). Among other things, this is because asbestos concentrations are reported as structure number concentrations, rather than mass concentrations.

It should also be noted that another method of reporting concentrations, the mass fraction of ACM in soils, is also discussed in this proposed SAP. This is the number of grams of ACM per unit mass of soil and it is determined simply by separating the ACM from the soil in which it resides, weighing each fraction, and taking the ratio. Such measurements should be distinguished either from measurements of the mass of asbestos in the ACM itself or from measurements of asbestos (as opposed to ACM) in soil. Each is determined by a different method, reported in a different manner, and used for a different purpose.

3.2 Project Management

This section describes the project management proposed for conducting the proposed work. A background discussion of issues and a definition of the specific problems being addressed at the North Ridge Estates Site is also presented along with a breakdown of proposed tasks.

3.2.1 Project/Task Organization

This section identifies various individuals and organizations that are expected to participate in this project, and discusses their responsibilities.

EPA Project Manager

The EPA Remedial Project Manager (EPA RPM), Alan Goodman (503-326-3685) reviews and approves the SAP/QAPP.

DEQ Project Manager

The DEQ Project Manager (DEQ PM), Cliff Walkey (541-388-6146), will be responsible for providing DEQ oversight and document review to assure that environmental investigation and cleanup are conducted in accordance with DEQ requirements.

Project Coordinator

The Project Coordinator (PBS PC), Dulcy Berri, RG (503-417-7591), PBS Engineering and Environmental (PBS) will be responsible for overall project and field work coordination pertaining to the site activities, project QA/QC, and field health and safety. The PC will oversee the preparation of the SAP/QAPP, implement the final version of the SAP/QAPP, maintain the official, approved SAP/QAPP, and document any deviations from the SAP/QAPP. The PC will have authority to assure that onsite project activities comply with the SAP/QAPP.

The PC will act as primary point of contact for communication with the EPA and DEQ, and will be the point of contact for all Respondent personnel performing onsite project tasks.

Principal Investigator

The project principal investigator, Dr. D. Wayne Berman (510-524-7855), Aeolus, Inc., will be responsible for technical components of the QAPP and laboratory QA/QC.

QA/QC Officer

The QA/QC Officer, Derek May (503-417-7602), PBS, will be responsible for auditing and reviewing the field and laboratory activities.

Project Managers

The Project Manager (PM) during activities involving air monitoring and bulk material sampling is Jeff Heeren (541-388-9290), PBS. The PM during contractor activities involving subsurface exploration and sampling is Colin Polk, RG (503-417-7590), PBS. The PM will be responsible for collecting samples as outlined in the SAP/QAPP.

Technical Staff

The Technical Staff, whether PBS or Aeolus staff, laboratory staff or other subconsultant staff, will report to the PC, Principal Investigator and QA/QC Officer as appropriate and are responsible for conducting all work in accordance with the SAP/QAPP. Each member of the Technical Staff will be aware of the project requirements that pertain to their job function; will implement this SAP/QAPP and project-specific quality requirements appropriately; will perform their portion of the work and report results in a professional manner; will monitor their own work quality and identify circumstances needing corrective actions; will perform data validation; and will otherwise follow the directions of the PC, Principal Investigator, QA/QC Officer and the PMs.

EMS QA Officer

EMS, Pasadena, California, will be providing air and bulk material sample analyses for this project. Tony Kolk, EMS's Quality Assurance Officer (EMS QA), will be responsible for QA/QC for all laboratory work conducted by EMS, and will report to the Principal Investigator to ensure the quality of the data produced by EMS. EMS will be subcontracted through Aeolus to conduct the laboratory analyses.

ESL QA Officer

Environmental Services Laboratory (ESL), Portland, Oregon, will be providing soil sample analyses for this project. ESL's QA Program Manager (ESL QA), Keith Hunter, will be responsible for QA/QC for all laboratory work conducted for this project by ESL and will report to the PC and the Principal Investigator to assure the quality of the data produced by ESL. The ESL QA will be the ESL point of contact for specific analytical questions. ESL will be subcontracted through PBS to conduct the laboratory analyses.

3.2.2 Problem Definition/Background

3.2.2.1 Problem

As a result of historic activities, asbestos construction debris and free asbestos have become distributed in soil around the site, and may present a human health threat to the current residential occupants. It is also possible that other COPC's may have been handled and released at the site and their presence needs to be confirmed.

3.2.2.2 Background

North Ridge Estates is located on the site of the former Klamath Falls Marine Recuperational Barracks facility, built in 1944 by the United States Department of Defense to receive and care for marines who may have contracted tropical diseases while fighting in the Pacific theater in World War II. More than 80

buildings were originally constructed to house, feed, and provide routine services and medical care to the troops.

In 1947, the Oregon Technical Institute (OTI) converted use of the facility to classroom, shops and garages, and many of the existing dormitories were occupied by students. OTI offered programs in various industrial arts, including diesel mechanics, electronics, automotive work, gunsmithing, medical technology, machine shop, welding and carpentry. Reports indicate that the facility buildings were deteriorating and in poor condition. OTI ceased operation at the site in 1964.

From 1966 through the mid-1970s, property owners reportedly stripped the vacant buildings of salvageable materials such as copper and wood. Asbestos insulation reportedly was stripped from piping and boilers, metal was sold, and the insulation remained at the site. The idle site was further subject to vandalism. As a result, asbestos debris was distributed around the site in surface soils, in piles and burial pits.

3.2.3 Project/Task Description

The following six tasks comprise the initial phase of the RI.

3.2.3.1 Task 1: Evaluate the adequacy of the current approach for assessing asbestos related risks

A number of models will be evaluated using existing and newly generated site data to determine the best method for predicting asbestos exposure within acceptable confidence limits. This will support the ability to define target acceptable concentration targets for asbestos in soils that can be applied during the final phase of the RI to help define the extent of required remediation.

3.2.3.2 Task 2: Evaluate the viability of candidate methods for supplementing characterization of the nature and extent of asbestos contamination

Several visual cues and simple markers will be evaluated (such as historical information, visual and other gross field indicators, and the mass fraction of ACM) to determine their utility as screening methods for delineating areas of asbestos contamination. A range of formal analytical methods will also be evaluated for correlations with asbestos content in soil (determined using the Modified Elutriator Method) and/or for correlation with exposure concentrations to determine whether any might serve as rapid and cost-efficient surrogates to supplement (or even supplant) use of the Modified Elutriator Method for use in the anticipated, comprehensive characterization of the site that will comprise the final phase of the RI.

3.2.3.3 Task 3: Confirm amphibole asbestos as a risk driver

Although, due primarily to the incorporation of very conservative assumptions, amphibole asbestos has been found to be a primary risk driver at the site (in addition to chrysotile asbestos), laboratory analyses to date have shown only very limited detection. It is proposed that existing samples be re-analyzed at greater sensitivity to determine if amphibole asbestos may be more prevalent than currently indicated or if it is indeed to be only rarely encountered at the site. This will provide information useful for deciding on the relative merits of further characterization versus making conservative assumptions about remediation for amphibole asbestos to facilitate design of the final phase of the RI.

3.2.3.4 Task 4: Obtain a preliminary indication of the distribution of asbestos contamination with depth

To date, there is only extremely limited information on the depth pf contamination and a general indication of the depth of contamination across the site would be extremely helpful for planning the design of the final phase of the RI, particularly regarding information concerning contamination at shallow depth. Therefore, it is proposed that samples be collected at selected locations across the site to evaluate the degree that asbestos contamination extends to at least shallow depths (on the order of 2 ft) across the site. Findings from this task will then be used in the manner previously described (Section 2.1.4) to facilitate design of the final phase of the RI.

3.2.3.5 Task 5: Search for the presence of COPCs other than asbestos

Information about historical activities suggests the possibility that other COPCs (other than asbestos) may be present, such as petroleum, dry cleaning fluids, power-station related PCBs, etc. Based on a compilation of historical documentation, a study to search for the presence of these other COPC's will be conducted. Confirming or refuting the presence of all COPC's alleged to be present at the site will facilitate final definition of the scope of COPC's that need to be considered as part of the final phase of the RI.

3.2.3.6 Task 6: Search for asbestos contamination at locations removed from the main portion of the site

Information about historical activities suggests the possibility that asbestos contamination may have been transported and deposited at locations removed from the main portion of the North Ridge Estates Site (where asbestos contamination is known to exist). Based on a compilation of historical documentation, a study to search for the presence of these other locations will be conducted. Confirming or refuting the presence of asbestos contamination

alleged to be present at these other locations will facilitate final definition of the extent of the site that needs to be considered as part of the final phase of the RI.

3.1.1. Quality Objectives and Criteria

The seven steps of the DQO process (U.S.EPA 2000) were introduced and applied to the relevant decisions identified for the proposed, initial phase of the RI in Section 2.1. Based on that application, an optimal field sampling plan that addresses each of the six objectives of the initial phase of this RI is defined in Sections 2.1.1 through 2.1.7. The methods and SOP's to be applied to collect, handle, prepare, and analyze samples and to collect other indirect data in support of the field sampling plan are provided in Section 3.4 below.

By applying the DQO process in the manner described, the overall quality requirements for the data sets to be generated in each of the proposed tasks have been defined and addressed. Quality requirements for individual analyses are also addressed because the analytical sensitivities, the overall precision, and even the accuracy of the individual analyses to be generated to create each data set have been also been defined.

3.3 Documents and Records

All documents and records will be organized and stored at PBS, which will also distribute such documents and records as required to complete the required work under all phases of the proposed RI for the North Ridge Estates Site. Specifically in the case of analytical data derived for asbestos analyses, raw data and the initial reduction/interpretation of raw data will be first acquired and stored at Aeolus, Inc.

Records of all activities associated with the collection, handling, and preparation of samples performed under this project are to be maintained in log-books. Copies of these will be collected at the end of each component task of the RI from the various facilities and individuals who conduct the work and these will form part of the permanent record of information for the RI.

For asbestos data, raw analytical results will be recorded on count sheets (for TEM analyses) and on record sheets (for other kinds of asbestos analyses) that will be provided separately to compliment the official laboratory reports (which will be provided in electronic format). In some cases, depending on the setup of each laboratory performing the required analyses, even the record of raw data will be provided in electronic format.

3.4 Data Generation and Acquisition

Procedures for sample collection, field and laboratory preparation, and laboratory analysis are cited and summarized below. Full texts for the various methods and SOP's cited are also provided in a companion set of appendixes.

3.4.1 Sampling Process Design

As previously indicated (Section 2.1), various types of sampling are to be conducted in support of each of the objectives of the proposed initial phase of the RI. The detailed procedures to be employed for selecting and marking sampling locations, sample collection, sample handling and preparation, and laboratory analysis are described below.

Because the overall design for selecting and marking sampling locations is unique to studies to be conducted to address each of the individual objectives of the initial phase of the RI, these are each addressed separately below.

3.4.1.1 Activity-based monitoring to support evaluation of the current procedure for assessing asbestos-related risk

As described in Section 2.1.1.3, a series of activity-based simulations are to be conducted to provide a database for supporting evaluation of the procedures currently being employed to assess asbestos-related risk at the North Ridge Estates Site. As currently proposed, simulations are to be conducted to evaluate child's play (loading and dumping of dirt), running, and bicycling over source areas that are selected because they exhibit a range of characteristics of potential interest (including a range of silt contents, moisture contents, and asbestos concentrations). Meteorological conditions are also to be monitored. An SOP describing the detailed manner in which simulations are to be conducted is provided in Appendix A.

A bench-scale laboratory study has also been proposed in Section 2.1.1.5 to provide better estimates of values for input variables to a model being employed to assess exposure (and risk) attributable to the direct handling of ACM. The procedures to be employed to conduct this laboratory experiment have already been described (Section 2.1.1.5).

3.4.1.2 Sampling to support evaluation of candidate methods for supplementing site characterization

As described in Section 2.1.2.2 samples are to be collected and analyzed to evaluate the reliability and sensitivity of a set of candidate screening procedures for the site and, separately, a set of formal analytical methods that can potentially serve as alternates to the Modified Elutriator Method. The nature of the samples

required to evaluate each set of methods are distinct. Thus, they are addressed separately below.

3.4.1.2.1 Sampling to support evaluation of screening procedures

To support the evaluation of screening procedures, as currently proposed (Section 2.1.2.2.1), a set of approximately 30 sampling locations are to be selected purposely to represent the broad diversity of conditions that have been encountered at the North Ridge Estates Site. At each such location, each of the candidate screening procedures is to be applied. Then, both a surface composite and a sub-surface composite are to be collected for the determination of asbestos and determination of ACM mass content. Additionally, samples are to be collected at each location (from both the surface and sub-surface) to characterize both silt and moisture content. An SOP is presented in Appendix B, which describes the detailed manner in which:

- sampling locations are to be selected;
- screening procedures are to be applied; and
- samples are to be collected, prepared, and analyzed for determination of asbestos content, ACM content, moisture content, and silt content.

It should be emphasized that the proposed scheme for evaluating screening procedures is focused specifically on considering factors that affect long-term risk. Thus, for example, with the exception of a small subset, samples to be analyzed for determination of asbestos as part of this procedure will retain the ACM component in the sample. The small subset of samples for which the ACM will be separated from the soil component of each sample are paired splits with samples that are to be analyzed without first separating out the ACM. Thus, these paired splits will be used to evaluate whether retaining the ACM in a sample when it is analyzed can adequately address contributions to overall asbestos concentrations from the embedded ACM.

Further, in addition to the samples analyzed for the determination of asbestos, the ACM content of sampled material at all sampled locations is also to be determined by two additional, independent methods (one qualitative and one quantitative). All of these procedures are being evaluated for their utility toward support of the comprehensive characterization of the site that is envisioned for the final phase of the RI.

3.4.1.2.2 Sampling to support evaluation of surrogate analytical methods

As indicated in Section 2.1.2.2.2, the utility of surrogate analytical methods for the determination of asbestos in soil will be evaluated both based on the quality of the correlation with measurements derived using the Modified Elutriator

Method and, independently, based on the quality of any correlations that might be observed between such measurements of asbestos in soil and the airborne exposure concentrations observed when such soil is disturbed so asbestos is released. As part of each comparison, the relative sensitivity of each method will also be noted.

The surrogate analytical methods to be evaluated as part of the initial phase of this RI are listed in Section 2.1.2.1 along with references to the available documentation for each such method. The detailed procedures required by each method for sample preparation and analysis are provided in the corresponding documentation that is referenced.

The data to be used to evaluate the above-described correlations will be generated from the analysis of the 14 samples to be collected to characterize source materials in support of the activity-based monitoring study proposed in Section 3.4.1.1 and Appendix A. As indicated in Appendix A, the amount of material to be collected in each of these samples will be sufficient to facilitate preparation and analysis by all of the surrogate methods under consideration. Moreover, material in each of these samples will be homogenized prior to splitting to assure comparability across analyses.

It should also be noted that, if any of the observed correlations are promising, additional samples (collected in support of other objectives of this initial phase of this RI) may also be split and analyzed by selected surrogate methods to increase the size of the data set available for correlating measurements respectively derived using each such surrogate and the modified elutriator method. However, because such samples will not be linked to airborne exposure concentrations (as they will not have been collected in association with the proposed activity-based monitoring study) they will not be useful for independently correlating soil measurements with airborne exposure measurements. As previously indicated, further analysis of any correlation between soil measurements (derived using methods other than the Modified Elutriator Method) and airborne exposure concentrations are beyond the scope of this RI and would more appropriately be addressed as part of a broader research effort.

Finally, if the utility of any of the surrogate methods can be demonstrated, calibrations may still be required. Any such calibrations will be completed by comparing paired analyses of a pre-determined number of field splits during the final phase of the proposed RI (as part of the comprehensive characterization that is envisioned for the site).

3.4.1.3 Sampling to support confirmation of amphibole asbestos as a risk driver

The EPA samples to be re-analyzed to support this objective were acquired by meeting with EPA staff at a location where the samples could be handled and split. The samples were then split by "coning and halving" (a procedure that is used broadly and is described, for example, in Chapter 8 of Berman and Kolk 1997). Appropriate chain of custody has been maintained for these samples throughout acquisition, transport, preparation, and analysis.

At the laboratory, samples are to be homogenized, split, prepared, elutriated, and analyzed using the stopping rules defined for an "extended analysis," which are all defined in Appendix C.

3.4.1.4 Sampling to support characterization of asbestos contamination at depth

As previously indicated, the set of approximately 30 sampling locations already discussed in Section 3.1.4.2 are to be sampled to provide a preliminary indication of the depth of contamination at the site. Details of the procedures to be used to collect, prepare, and analyze these samples are provided in Appendix B; the nature of the locations to be sampled are summarized in Table B-1.

3.4.1.5 Sampling to search for the presence of COPC's other than asbestos

Soil sampling will be conducted in those areas identified as per Section 2.1.5 as having a substantial potential for non-asbestos COPCs to be present. Samples will be collected at appropriate depths, e.g. in the vicinity of the former gasoline service station, samples would be collected from the presumed depth of underground storage tanks. Based on the depth required to evaluate the concern, samples may be collected by hand (trowel, shovel, hand auger) or with other equipment (backhoe, GeoProbe sampling rig).

Sample locations in the vicinity of an area of concern will be distributed areally and in sufficient numbers to maximize the likelihood of detecting COPCs, if present. A minimum of two discrete soil samples will be collected from any area of potential concern, although generally a somewhat larger number may be required. The number and location of samples to be collected to evaluate the presence of COPCs at any particular location will be finalized in collaboration with EPA staff.

Each sampling location will be identified by GPS measurement, which along with sample depth will be recorded. Soil characteristics important to the interpretation of laboratory findings will be noted, such as relative soil moisture, soil color and

type, presence of odors or discoloration, presence of construction debris, ACM, etc.

Depending on the nature of the historical activity and potential COPCs that may be present, other investigative techniques may be deemed appropriate, such as use of geophysical survey equipment.

Details of the procedures to be used to collect, prepare, and analyze these samples are provided in Appendix D.

3.4.2 Sampling Methods

3.4.2.1 Soil Sampling

All samples will be placed in appropriate containers for shipment to the laboratory. The specific types of containers to be used for each type of sample are identified in the various SOP's that describe the detailed procedures to be used for sample collection, handling, packaging, labeling, preparation, and analysis.

During collection of solid material samples, the sampler will wear a clean pair of disposable gloves. Samples will be maintained under chain-of-custody by the sample collection personnel until shipped or hand-delivered to the laboratory. It is anticipated that samples will be shipped on a daily basis. The sample collector is responsible for prompt shipping of samples and the laboratory QA PM is responsible for extracting the samples, if appropriate, within the acceptable time limits for each sampling method.

The sampling process design section (Section 3.4.1) describes the anticipated numbers and types of samples expected to be collected during this project. The exact numbers and types of samples may also be determined onsite during the work, and may also vary depending upon the discovery of unanticipated field conditions. Sample containers, holding time, and preservative requirements for each matrix to be sampled are presented in the full text of corresponding SOPs in the Appendices.

3.4.2.2 Air Sampling

Air samples will be taken using a pump and filter cassette arrangement through which the air is drawn. Particulate is deposited on the filter, which can subsequently be analyzed, or through a cyclone which can be weighed after sampling.

Low volume personal pumps will be the primary equipment used to collect air samples. These pumps are battery-operated and can be clipped to a belt or other harness to be carried around while air is sampled. The pumps operate at

1.0 to 2.5 liters per minute flow rates and utilize a 0.45 micron mixed cellulose ester membrane filter for TEM analysis or other as appropriate to the intended analytical method. Additional sample equipment criteria may be found in the corresponding SOPs in the Appendices.

3.4.3 Sample Handling and Custody

This section summarizes sample identification, handling, management, documentation, document control, custody, and scheduling requirements. Custody procedures will assure that accurate and complete records of sample collection, sample transfer between personnel, sample shipment, and sample receiving by the laboratory are generated and retained.

3.4.3.1 Sample Labeling

Each sample to be shipped for laboratory analysis will be labeled with a unique number that will include the sample site identification number and the date that the sample is collected. Specific numbering systems are proposed in each of the SOPs.

3.4.3.2 Decontamination of Field Equipment

Prior to use in the field, the equipment used for all samples collected for asbestos identification (e.g. trowels and templates) will be decontaminated by washing with biodegradable soap, rinsing with asbestos-free water, and drying either with asbestos-free cloth rag or forced air. If forced air is used, it must be HEPA filtered to assure that it remains asbestos-free. Sampling equipment will be similarly decontaminated prior to removing it from the site.

Between collection of individual soil samples, sampling equipment may be wiped clean with a clean, asbestos-free cloth rag.

Wash and rinse water will be collected and containerized; any disposable materials used for decontamination (e.g. rags) will be disposed with ACM waste.

Other, or additional decontamination methods may be necessary for other sample media and potential COPCs to be test for, and are included in the appropriate SOPs.

3.4.3.3 Documentation

The following information will be recorded for each soil sample collected during this project:

-the sample identifier;
-the time or time period over which the sample was collected;
-the GPS location of the sample;
-any required modifications to the location initially selected for sample collection along with the reasons (i.e. the nature of any field obstructions) for needing such modification;
-any changes or modifications required to the indicated procedures for sample collection;
-relevant observations concerning the location (presence of vegetation, color and condition of soil, if applicable; relative apparent moisture content, etc.) from which the sample is collected (to be supplemented with photographs);
-documentation of ACM (size, nature, color, type, etc.) observed at the sample location; and
-any other, potentially relevant information concerning the conditions under which the sample is collected or as required by the SOP (e.g. any required weights or similar information).

Breakable containers will be bubble-wrapped as needed, and maintained under chain-of-custody by the PBS PM or other sampling personnel until shipped or hand-delivered to the laboratory. It is anticipated that samples will be shipped on a daily basis. The PBS PM will coordinate with the analytical laboratory in order to ensure that all sample shipments are received by laboratory personnel in an appropriate time frame, and to minimize sample transport and holding time.

3.4.3.4 Chain of Custody

The Project Coordinator's representative will manage sample handling, transport and storage with appropriate Chain-of-Custody documentation

The Chain-of-Custody (COC) protocol begins with sample collection and ends with sample disposal, and creates a document for each sample during this time frame; under no circumstances is there to be a break in custody. A COC form will be completed by staff for each sample collected, and will remain with the samples until receipt in the laboratory.

At the time samples are delivered to the commercial carrier the Technical Staff will:

- Sign, date, and time the chain of custody under "relinquished by", and identify the commercial carrier on the COC under "received by"
- Place the COC in a Ziploc bag and tape to the inside top of the container
- Secure the container with tape custody seals so that the container cannot be opened without disturbing the seal

At the time custody transfers from the carrier to the laboratory, the laboratory's sample custodian will perform the following:

Indicate the commercial carrier on the COC under "relinquished by"
Sign, date, and time the COC under "received by"

The laboratory will note the condition of received samples on the COC, including temperature (if appropriate). Each laboratory's QA PM is responsible for laboratory sample handling and storage and for ultimate disposal of samples.

Sample containers and filter cassettes will be provided direct from the manufacturer via the respective laboratories.

Staff responsible for sampling will inspect all sampling containers and cassettes prior to use.

3.4.4 Analytical Methods

Many of the analytical methods proposed during this project have been noted in the preceding sections; these and others that may potentially be used are listed below, and copies of each method are included in Appendix E.

Asbestos in Air

NIOSH 7402 – TEM analysis

NIOSH 0600 – Respirable particulates

ISO 10312 – TEM analysis

Asbestos in Soil

Modified Elutriator Method (Berman and Kolk 2000)

Superfund Method (Berman & Kolk 1997)

Perkins and Harvey 1993

Kolk (no date)

PLM SOP developed for soil at the Libby, Montana site

TEM SOP developed for soil at the Libby, Montana site

Other COPCs in Soil

Petroleum Hydrocarbons (NWTPH-HCID, NWTPH-Gx, NWTPH-Dx)

Polynuclear Aromatic Hydrocarbons (PAHs) (EPA Method 8270D)

Polychlorinated Biphenyl Compounds (PCBs) (EPA Method 8082)

Total and Leachable Heavy Metals (EPA Methods 1311, 6010 and 7000)

Volatile Organic Compounds (EPA Method 8260B)

Other Laboratory Procedures
Moisture Content (ASTM D 2216-05)
Silt Content – Dry Method (ASTM C 136-04)
Fines Content – Wet Method (ASTM C 117-04)

3.4.5 Quality Assurance/Quality Control

The Qualiity Control (QC) procedures to be employed to track the reliability of the sampling and analytical efforts in this project are defined for specific tasks in each specific SOP.

Regarding Quality Assurance (QA), all procedures to be used for sample collection, handling, packaging, labeling, preparation, and analysis and all equipment handling, use, and decontamination procedures applied in this project are documented in writing. Moreover, the details of all work will be logged to provide a written record that can be checked against the planned work. Any deviations from the written procedures will be recorded in an appropriate log.

In addition, all laboratories to be employed for sample analysis will be appropriately certified and will operate with a written in-house QA/QC plan. Whether laboratories to be employed will need to be audited over the course of the project is an issue that will be decided in cooperation with EPA.

3.4.6 Instrument/Equipment Testing, Inspection, and Maintenance

Field instruments expected to be used during this project include a hand-held PID; low volume BDX and SKC air sampling pumps; Mini-Buck calibrator; low volume field rotometer and micro-flow rotometer (secondary calibration); and Gast, MSA and Draeger sorbent tubes and pumps. All field equipment and instruments will be tested, inspected and maintained by the equipment operator, per the published instructions for that piece of equipment. Fresh batteries will be used as necessary.

All laboratory instruments and equipment used during fixed laboratory sample analyses will be operated, inspected, and maintained according to the manufacturer's instructions as well as the specifications delineated in each specific sampling method and by each laboratory's QA/QC manual.

3.4.7 Instrument/Equipment Calibration and Frequency

Field instruments will be calibrated on a daily basis, prior to the commencement of measurements with that instrument, according to the instrument manufacturer's directions, using fresh calibration standards.

Optimal functioning of air sampling pumps and other equipment requires daily inspection and regular scheduled maintenance by trained personnel. Each PM is responsible for proper functioning of equipment in his/her possession. If malfunction of equipment is suspected, the PM must inform the QC Officer immediately.

Air sampling pumps will be calibrated before and after use with a field rotometer, that is itself calibrated to a primary precision flowmeter (MiniBuck) at least every six months. Low-flow pump flow rates are deemed accurate to +/- 0.1 liters per minute. All equipment to be used in support of sampling will undergo routine maintenance to assure optimal functioning.

Regular maintenance or repair of equipment is the responsibility of the PM to schedule. Only trained service technicians are used for maintenance and repair work, and records are kept of date, equipment identification, and nature of work performed.

All laboratory instruments and equipment used during fixed laboratory sample analyses will be calibrated according to the manufacturer's instructions as well as specifications delineated by each laboratory's QA/QC manual.

3.4.8 Inspection/Acceptance of Supplies and Consumables

Materials used in the execution of work will be appropriate and approved for intended uses. The procurement and handling of quality-affecting materials will be controlled to ensure initial and continued conformance with applicable technical requirements and acceptance criteria. These items will be visually inspected before shipment to the field and again before use. Inspection elements will include, as appropriate, a review of physical condition, expiration dates, limitations of use, size and quantity, and quality grade (e.g., reagents and solvents). Quality-affecting materials that are to be controlled include, but are not limited to, sample bottles and canisters, calibration standards for field equipment, sample preservatives, disposable sampling supplies, and disposable PPE. Materials that do not meet performance specifications will be segregated and labeled to preclude use.

Sample containers and filters will be provided by the laboratory and are expected to be direct from the manufacturer. Disposable gloves for project use will be obtained directly from the box provided by the manufacturer and will be kept clean prior to onsite use.

Each laboratory is responsible for inspecting and accepting reagents and other laboratory supplies according to their in-house QA/QC procedures.

3.4.9 Non-Direct Measurements

No non-direct measurements are proposed for collection at this time.

3.5 **Data Management**

The PC is responsible for maintaining the project files and keeping copies of all generated data in the project files.

Field notes and other records are described in appropriate SOPs. A copy of all field-generated data will be provided to the PC for storage in the project files.

Laboratory reports for each sampling media and event will be provided in hard copy format to the QA Officer and the PC for storage in the project files. Laboratory reports should include, at a minimum, each sample identification number, units for reporting, a numerical value for any "less than" or "non-detect" results, laboratory QA/QC data, any data qualifiers, including their definition, and a copy of the completed chain-of-custody form. The laboratories are requested to provide electronic copies of all laboratory reports to the QA Officer upon completion of testing. These will include .pdf files of the reports.

The QA Officer will oversee inclusion of the data in tabular and written format.

3.6 **Assessment and Oversight**

3.6.1 Assessments and Response Actions

Assessments used during implementation of the project will include frequent communications and updates during fieldwork between the PC and QA Officer, and between site personnel including the PC and Field PM.

The DEQ or EPA RPM, as appropriate, will have the responsibility to initiate any required response actions associated with findings identified during site audits. The PC will be responsible for overseeing implementation of any response actions. Once the response action has been implemented, the DEQ or EPA RPM may perform a follow-up audit to verify and document that the response action was properly implemented.

Field personnel will conduct frequent surveillance of project activities and records to as

sure that the elements of the QAPP are being properly implemented. Each laboratory will be responsible for conducting statistical data quality assessments as specified by the analytical method and in the laboratory's in-house QA/QC manual.

3.6.2 Reports to Management

The PC will be responsible for providing periodic verbal updates to the EPA RPM as well as monthly reports. These updates will include a discussion of project status and schedule, any encountered QA problems and recommended solutions, and data quality assessments.

As each task of the project is completed, written records, field maps and notes, laboratory reports, etc. will be provided to the PC for inclusion in the project files.

3.7 Data Validation and Useability

Data generated during this project will be evaluated by reviewing quality assurance documentation to assure that samples have been handled (collected, prepared, and analyzed) as proposed and by reviewing the supporting quality control data generated in tandem with project data to evaluate whether stated data quality objectives have been achieved.

3.7.1 Data Review, Verification, and Validation

When laboratory reports are received, the reports will be reviewed to assess data completeness and whether reporting requirements have been satisfied. The associated quality control data will also be evaluated to assure that laboratory performance satisfies expectations and to evaluate whether the relevant data quality objectives (as defined in Section 2.1) have been satisfied. If objectives are achieved, the data will be considered to be valid and useable for their stated purposes.

If data quality objectives are not satisfied for particular batches of samples, the relevant quality assurance documentation will be reviewed and the associated quality control data will be evaluated in an attempt to identify the source of the problem. At that point, decisions will be rendered concerning whether corrective action is required and/or the level of data quality achieved is still sufficient to proceed with data evaluation to support the goals of the study. If corrective action is required, the QC officer (and Aeolus, for asbestos data) will work with the team members responsible for generating the problem data to see what actions may be required to fix the problem and whether the data can be repaired or replacement data generated.

3.7.2 Verification and Validation Methods

Data validation and usability elements address the QA activities that occur after the data has been collected. Implementation of these elements determines whether the data conform to the specified criteria, thus satisfying the project objectives.

Field procedures for data review, verification, and validation will include comparing all COC forms, sample labels, and field notes for agreement prior to sample shipping.

At each laboratory, laboratory procedures include three levels of review: during sample log-in, at the bench level while analyzing samples, and upon completion of a batch of samples. During sample log-in, laboratory personnel will compare COC forms with received sample containers and note any inconsistencies. At the bench level during sample analysis, all calculations and logbook entries will be reviewed by a second analyst for errors, and may be reviewed by the area supervisor. Upon completion of a batch of samples, the laboratory QA PM will conduct a third review of data accuracy. Any variations noted by laboratory personnel during the analysis process will be described in writing in the laboratory report for that data set.

The QA Officer and laboratory QA/QC officer will ensure that any analytical data variances are included in their discussion/analysis of the laboratory data. Any variations to the sampling plans will be documented in the field by the PBS PM.

3.7.3 Reconciliation and User Requirements

These are defined in Section 2.1.

4 SCHEDULE – INITIAL PHASE OF THE RI

Submission of the SAP/QAPP to EPA	July 7, 2005
Activity-Based Sampling	Within 30 days of approval of the SAP/QAPP
Evaluate Candidate Screening Methods	
Evaluate Amphibole Asbestos as a Risk Drivers	
Determine Asbestos Distribution with Depth	
Evaluate for Non-Asbestos COPCs	
Investigate Locations Outside of the Primary Area of the Site Where Additional Asbestos Contamination is Alleged	
Revise the SAP/QAPP to incorporate Final Phase of the RI tasks Based on findings of the Initial Phase	Commence upon completion of Initial Phase of the RI tasks
Submit Revised SAP/QAPP to EPA	Within 45 days of completion of Initial Phase of the RI tasks

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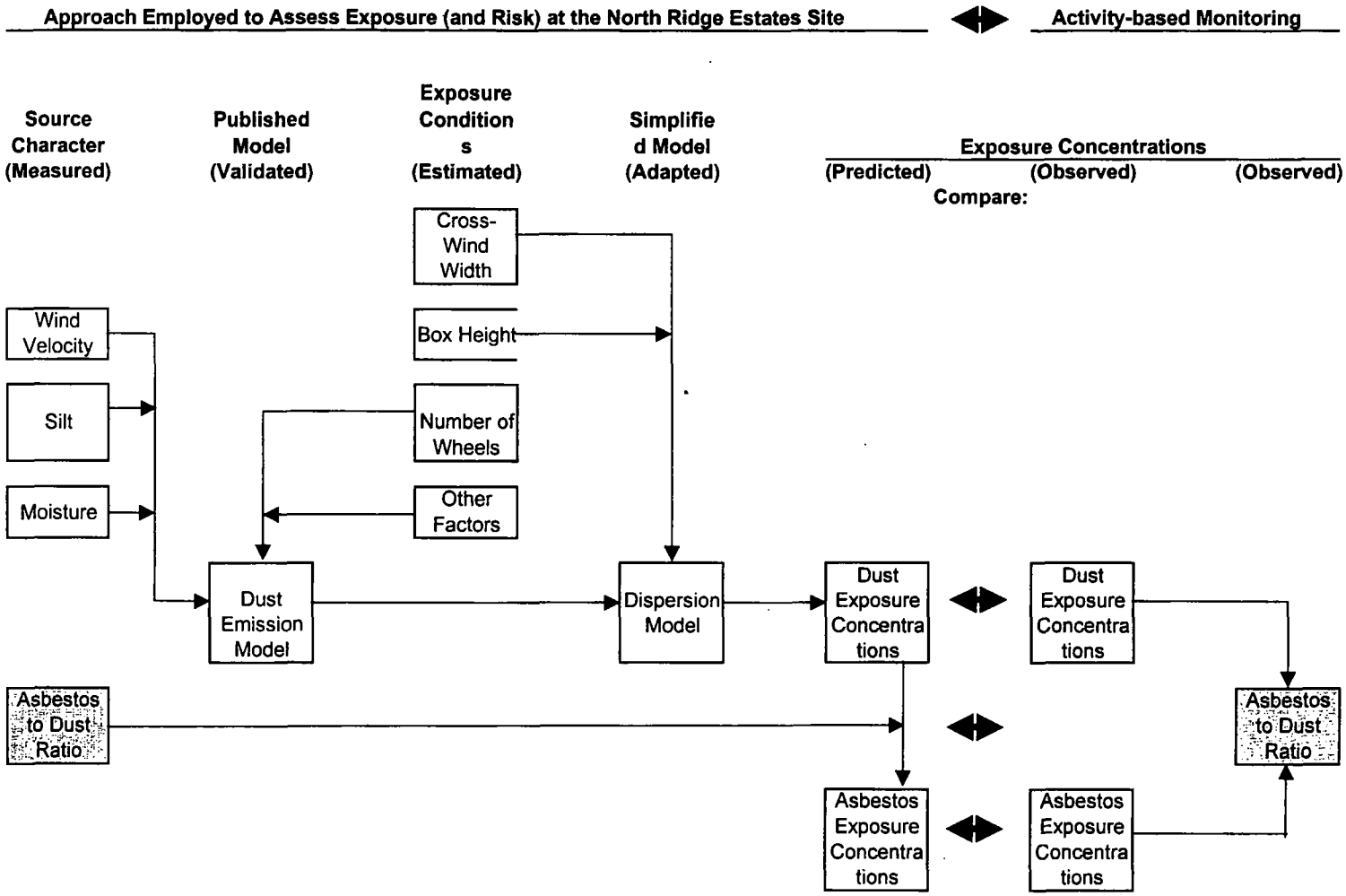
6 FIGURES

Figure 1
SCHEMATIC OF STUDY TO EVALUATE THE RELIABILITY OF THE APPROACH USED TO ASSESS EXPOSURE AND RISK AT THE NORTH RIDGE ESTATES SITE KLAMATH FALLS, OREGON



7 TABLES

TABLE 1:
DESIGN FEATURES OF THE PROPOSED ACTIVITY-BASED SAMPLING STUDY UNDER THE INITIAL PHASE OF THE RI/FS FOR NORTH RIDGE ESTATES, KLAMATH FALLS, OREGON

Activity	Type of Analyses	Number of Sites[a]	Number of Repetitions per Site[b]	Number of Analyses per Repetition[c]	Total Number of Analyses[d]	Total Number of Predictions[e]
Child's play						
	Asbestos	**2**	**3**	**2**	**9**	6
	Dust				**12**	6
	Only Dust[f]					
Running						
	Asbestos	1	3	4	9	3
	Dust				12	3
	Only Dust[f]	1	2	4	8	2
Bicycling						
	Asbestos					
	Dust					
	Only Dust[f]	2	3	**4**	24	6

Notes

[a] These are the total number of separate source areas at which a simulation of each of the indicated activities will be conducted.

[b] This is the number of times that a particular activity will be simulated at each source area.

[c] Because samples are to be collected from multiple locations in the vicinity of the exposure area for individuals involved in each activity, this is the number of analyses that will be collected of the specified type during each repitition of each activity.

[d] This is the total number of analyses of each type to be collected for each activity. It is simply the product of the numbers in the corresponding cells of Columns 3, 4, and 5.

[e] Because predictions are based on models that average dispersion over a box covering the entire exposure area, only one prediction is developed per repitition of each activity. Thus, the number of predictions is equal to the product of the numbers in the corresponding cells of Columns 3 and 4.

[f] The experiments listed in this row will be conducted in non-contaminated areas and will involve collection of repirable dust samples only (no asbestos samples will be collected).

TABLE 2:
DESIGN FEATURES FOR SOURCE CHARACTERIZATION DURING THE PROPOSED ACTIVITY-BASED SAMPLING STUDY UNDER THE INITIAL PHASE OF THE RI/FS FOR NORTH RIDGE ESTATES, KLAMATH FALLS, OREGON

Activity	Type of Analysis	Number of Sites	Number of Analyses per Site	Total Number of Analyses
Child's Play				
	asbestos	2	3	6
	silt	2	3	6
	moisture	2	4	8
Running				
	asbestos	1	8	8
	silt	2	8	16
	moisture	2	4	8
Bicycling				
	asbestos	0	0	0
	silt	2	8	16
	moisture	2	4	8

TABLE 3:
SIZES OF DATA SETS TO BE GENERATED FROM THE PROPOSED ACTIVITY-BASED MONITORING TO BE CONDUCTED DURING THE RI/FS FOR THE NORTH RIDGE ESTATES SITE, KLAMATH FALLS, OREGONa

Activity[b]	Number of Prediction:Observation Pairs		
	Dust	Asbestos	$R_{a/d}$
Child's Play	6	8[a]	9[c]
Running	5[d]	3	9[c]
Bicycling	6[e]	0[e]	0[e]
Rototilling	0	2[a]	0
Total:	**17**	**13**	**18**

NOTES:

[a] Includes relevant data from the activity-based monitoring study conducted by EPA in 2004.

[b] Excludes the data collected by EPA for weed-trimming because this pathway was never modeled so that there are no predictions with which to pair measurements. Results from EPA monitoring suggest that this pathway is not a concern in any case.

[c] As indicated in the text, there are more paired measurements for comparing asbetos-to-dust ratios generated using the Modified Elutriator Method than pairs of exposure predictions and observations, because samples are collected from multiple locations within the exposure zone.

[d] Includes data from experiments in which only dust will be monitored.

[e] As currently anticipated, bicycling will be studied for dust emissions only.

TABLE 4

ESTIMATED CONCENTRATIONS OF ASBESTOS IN SOILS POTENTIALLY CAPABLE OF GENERATING EXPOSURE EQUIVALENT TO INDICATED LEVEL OF RISK FOR RESIDENTIAL EXPOSURE PATHWAYS RELEVANT TO THE NORTH RIDGE ESTATES SITE, KLAMATH FALLS,OREGON

Structure Types	Asbestos Types	Target Risk Levels $1x10^{-4}$ [a]	$1x10^{-5}$ [b]	$1x10^{-6}$ [c]	Units
Protocol Structures[d]					
	Chrysotile	4.E+07	4.E+06	**4.E+05**	s/g_{PM10}
	Amphibole	**6.E+05**	**6.E+04**	**6.E+03**	s/g_{PM10}
7402 Structures[e]					
	Chrysotile	2.E+07	2.E+06	**2.E+05**	s/g_{PM10}
	Amphibole	2.E+07	2.E+06	**2.E+05**	s/g_{PM10}

Notes:

[a] This is the upper end of the range of risks potentially considered acceptable by the U.S.EPA.

[b] This is the maximum risk potentially considered acceptable by the ODEQ when risks are evaluated probabilistically.

[c] This is the maximum risk potentially considered acceptable by the ODEQ when risks are evaluated deterministically.

[d] These are equivalent soil concentrations for each target risk estimated based on the most critical exposure pathway previously identified for the site (Berman 2004, 2005) and assuming that risk is evaluated using the Berman and Crump (2001) protocol.

[e] These are equivalent soil concentrations for each target risk estimated based on the most critical exposure pathway previously identified for the site (Berman 2004, 2005) and assuming that risk is evaluated using the current EPA approach (IRIS 1988).

APPENDICES:

APPENDIX A – SOP for Activity-Based Monitoring
APPENDIX B – SOP for Evaluating Screening Procedures
APPENDIX C – SOP for Extended Analysis of Composite Samples to Provide an Improved Understanding of the Occurrence of Amphibole
APPENDIX D – SOP for Evaluating COPCs other than Asbestos

APPENDIX E - SOPs for Laboratory Tests/Analytical Methods
(Volume 2 – Bound Separately)


PBS

APPENDIX A:

STANDARD OPERATING PROCEDURE FOR CONDUCTING ACTIVITY-BASED MONITORING STUDIES

NORTH RIDGE ESTATES
KLAMATH FALLS, OREGON

Appendix A
SOP for Conducting Activity-Based Monitoring Studies
North Ridge Estates, Klamath Falls, Oregon

STANDARD OPERATING PROCEDURE FOR CONDUCTING ACTIVITY-BASED MONITORING STUDIES AT THE NORTH RIDGE ESTATES SITE, KLAMATH FALLS, OREGON

D. Wayne Berman, Ph.D.
Aeolus, Inc.
July 7, 2005

During the initial phase of the RI, as currently proposed, simulations are to be conducted to evaluate child's play (loading and dumping of dirt), running, and bicycling over source areas that are selected because they exhibit a range of characteristics of potential interest (including a range of silt contents, moisture contents, and asbestos concentrations). Meteorological conditions are also to be monitored. It is proposed that the specific source areas over which the simulations are to be conducted be selected in collaboration with EPA staff.

This SOP describes the detailed procedures to be used to characterize source areas, conduct the simulations, monitor exposure concentrations, and monitor meteorological conditions.

1. Procedures for Characterizing Source Areas[1]

The relevant bulk characteristics of all source areas (including silt content, ACM concentration, and the concentration of free asbestos) are to be determined by sampling and analysis, prior to conducting any simulations. Due to its potential variability, samples for the determination of moisture content are to be collected immediately before and/or immediately after conducting a simulation at a particular source area.

Because the required sizes for source areas differ depending on which activity is to be simulated, procedures for characterizing each type of source area are described separately below.

1.1. Procedures for Characterizing Source Areas in Conjunction with Simulating Child's Play

Source areas for simulating child's play are to be square in shape and approximately 16 m^2 in size (i.e. approximately 4 m on a side). Each area shall

[1] The procedures presented here have been modified to assure that sufficient volumes of sample are collected to allow preparation and analysis by multiple methods. This is to satisfy both the requirements for supporting evaluation of the risk assessment approach (as described here) and requirements for supporting evaluation of candidate methods for supplementing site characterization (Section 2.1.2).

be divided into four equal quadrants that are each 4 m^2. The boundaries of these areas shall be clearly demarcated with tape, chalk, or environmentally-friendly paint.

Four types of samples are to be collected from each sampling location:

- the first sample type is to be analyzed for the determination of asbestos content;
- the second sample type is to be analyzed for the determination of ACM content;
- the third sample type is to be analyzed for the determination of silt content; and
- the fourth sample type is to be analyzed for the determination of moisture content.

The first three sample types are each to be composites constructed from four component samples with one component collected from a pre-selected, random location from within each of the four grid squares (quadrants) of the sampling grid. For each of these sample types, three independent composites will be constructed (each composed of an independent set of four component samples), which will each be analyzed and compared to evaluate spatial variability.

Moisture content samples will not be composited. Instead (either immediately before or immediately after simulations are conducted in a source area), a single sample will be collected from the center of each quadrant of the source area and each of these will be separately packaged and sent for analysis for moisture content.

The manner in which each sample type is to be collected, prepared, labeled, and packaged is described below.

1.1.1. Procedures for collection of composite samples for determination of asbestos

As previously indicated, composites for determination of asbestos are to be constructed by combining material from four component samples each collected from a pre-selected, random location within one of the four grid squares (quadrants) of the sampling grids.

Note, component samples for composites collected for the determination of asbestos, for composites collected for the determination of ACM

content, and for composites collected for the determination of silt content are to be collected from the same locations, and the order in which the samples are collected is important. Asbestos samples are to be collected first followed by samples for ACM content with samples for silt content collected last.

Component samples are to be collected for asbestos determination as follows:

1. at each defined (random) location within each of the four grid squares, the surface to be sampled (a square area that is approximately 30 cm on a side) is first to be cleared of vegetation, biological debris, stones, and any construction debris that is obviously non-ACM. Gently hand-pick these materials and remove them from the sampling area. If the area to be sampled is heavily vegetated, it may first be cleared using a scythe or other cutting tool;

2. once cleared, use a clean trowel in a reproducible manner to scrape material from a one-inch depth centered on the identified sampling location, until the trowel is sufficiently full to satisfy Step 3;

3. gently pour the material from the trowel into a clean container with a mark indicating a volume of 250 cm^3 (approximately one cup, English units). This is to be termed a "transfer container." If the presence of a larger piece of debris, rock, or other solid object is picked up by the trowel but is too large to reasonably include within the indicated sample volume (i.e. if it comprises more than one half of the volume of the sample), remove the object, characterize it as potential ACM or non-ACM and note the modification to the sample in the field log. Also, continue filling the transfer container to replace the volume removed. If the object is not ACM, it may be discarded. If the object is ACM (or apparent ACM), it should be separately bagged, labeled, and shipped to the laboratory as an object associated with the particular sample.

   Note, ideally the transfer container can be filled with an integer number of trowel scoops (one or two). If not, be careful to transfer material from the trowel to the transfer container using a procedure that will not result in size-selective transfer. For example, do not tilt the trowel so that a particular layer on the trowel pours into the container. Rather, use a knife or spatula to divide the material in the trowel vertically and introduce all of the material from the divider forward into the container;

4. quantitatively transfer the component sample from the transfer container to a clean, pre-weighed sample container (of sufficient size to hold the combined

material) and combine all four component samples of a particular composite into the same sample container; and

5. determine the mass (to the nearest 0.2 g), label, and prepare the sealed containers for shipment.

Importantly, it is generally unlikely that so much of a 144 square-inch area (demarcated by a template) around a selected sampling location would be comprised of rocks, construction debris, or other materials that make collection of a sample impossible. However, in the rare case the sampling is found to be impossible, the sampling location is to be moved 12 inches to the due south and the fact that the sampling location had to be moved is to be noted in the field log. In the remote possibility that sampling at this first-alternate location is also impossible, the sample location may be moved an additional 12 inches due south, as long as this second change is also noted in the field log. Such modifications may be repeated up to four times, if absolutely necessary, until a suitable location for sampling is encountered. However, any such modification of location must only be because more than half of the template area of a previous location is impossible to sample. This same modification can also be applied to each of the other three sampling types.

1.1.2. Procedures for collection of composite samples for determination of ACM

As previously indicated, composites for determination of ACM content are to be constructed by combining material from four component samples each collected from a pre-selected, random location within one of the four grid squares (quadrants) of the sampling grids. Procedures for collection of samples are described below.

Once the component sample has been collected for the composite for determination of asbestos, the component sample for determination of ACM content is to be collected from the same location in the following manner:

1. place a 30-cm (12-inch) template on the ground so that it is centered over the location from which the component sample was previously collected for the determination of asbestos;

2. using a trowel, scoop dirt from within the *entire* template to a depth of one inch and place the material in a pre-weighed (to the nearest 10 g), 5-gal bucket;

3. combine material from all four component samples into the same, pre-weighed bucket;

4. once all the material from the components of a particular composite are combined, weigh the bucket, determine the mass of the material to the nearest 10 g and record the mass in the field log;

5. place a sieve with 1-cm (3/8ths-inch) openings over a second bucket and sieve the material from the weighted bucket into the new bucket. Gently work the material on the sieve so that the fines pass through. Then, examine the material caught on the sieve and remove all objects that are obviously not ACM (e.g. rocks or concrete construction debris). Any material left on the sieve that is potentially ACM should then be transferred quantitatively to another pre-weighed container;

6. determine the mass of the ACM from each composite to the nearest 0.2 g and record the mass in the field log. Importantly, weighing of the original material from an entire composite and the ACM from the same composite must occur within 30 minutes of each other to minimize the chance that weights will be affected by changes in moisture content;

7. once weighing of the ACM is complete, the fines from the composite should be containerized and disposed of as asbestos-contaminated waste.. The ACM shall be sealed in a plastic bag, properly labeled, and stored for possible shipment to the laboratory for analysis at a later date.

1.1.3. Procedures for collection of composite samples for determination of silt content

A minimum of 1 L (2 kg) of material is to be collected for determination of silt content. As currently planned, the material from the samples collected is to be sealed in a 1-gal Ziploc bag. Following collection of the sample for determination of ACM content, samples for silt content shall be collected by:

1. within each of the four grid squares, component silt content samples are to be collected from a location immediately adjacent to and north of the square from which the sample was previously removed for determination of ACM content;

2. use a clean trowel in a reproducible manner to scrape material from a one-inch depth centered on the identified sampling location, until the trowel is sufficiently full to satisfy Step 3;

3. gently pour the material from the trowel into a clean transfer container with a mark indicating a volume of 250 cm^3 (approximately one cup, English units). If the presence of a larger piece of debris, rock, or other solid object is picked up by the trowel but is too large to reasonably include within the indicated

sample volume (i.e. if it comprises more than one half of the volume of the sample), remove the object and note the modification to the sample in the field log. Any such object can then be disposed of *in an appropriate manner* that will depend on whether the object is ACM. Also, continue filling the transfer container to replace the volume removed.

Note, ideally the transfer container can be filled with an integer number of trowel scoops (one or two). If not, be careful to transfer material from the trowel to the container using a procedure that will not result in size-selective transfer. For example, do not tilt the trowel so that a particular layer on the trowel pours into the container. Rather, use a knife or spatula to divide the material in the trowel vertically and introduce all of the material from the divider forward into the container;

4. quantitatively transfer the component sample from the transfer container to a clean, pre-weighed 1-gal Ziploc bag and combine all four component samples of a particular composite into the same bag; and

5. determine the mass (to the nearest 0.2 g), label, and prepare the sealed containers for shipment.

1.1.4. Procedures for collection of samples for determination of moisture content

As previously indicated, moisture content samples are *not* composited. Rather, a single sample is to be collected from the center of each quadrant of each source area of the child's play scenario that is to be characterized and each of these four samples are to be separately weighed, packaged, labeled, and sent to the laboratory. Also, these samples are to be collected either immediately before or immediately after the actual simulations are conducted (rather than in advance as with the other sample types discussed above).

To collect samples for moisture content:

1. place a 30-cm (12-inch) template on the ground so that it is centered over the selected sampling location;

2. use a trowel to scoop dirt from within the template to a depth of one inch. The material collected is to be placed in a (pre-weighed) 1-gal, heavy gauge, Ziploc bag;

3. specifically for these samples, once filled, it is important to create an air-tight seal on the sampling container. Thus, be sure to seal the Ziploc bags completely and to test them to be sure that the seal is air tight; and

4. weigh the bag (to the nearest 0.2 g), label, and prepare the sealed containers for shipment to the laboratory.

1.2. Procedures for Characterizing Source Areas in Conjunction with Simulating Running

Source areas for simulating running are to be annular in shape and the outer diameter is to be approximately 70 m. This corresponds to a circumference of approximately 220 m or a bit more than an eighth of a mile. The annulus is to be 1.5 m wide for a total surface area of approximately 630 m^2. Both the inner and outer boundaries of the annulus shall be clearly demarcated with tape, chalk, or environmentally-friendly paint. The annulus is also to be divided into four equal quadrants that each represent 90° of arc (corresponding, for example, to the northeast quadrant, southeast quadrant, southwest quadrant, and northwest quadrant) and the boundaries between the quadrants are also to be clearly demarcated. Note that each quadrant has a surface area of approximately 160 m^2.

Four types of samples are to be collected from each sampling location:

- the first sample type is to be analyzed for the determination of asbestos content;
- the second sample type is to be analyzed for the determination of ACM content;
- the third sample type is to be analyzed for the determination of silt content; and
- the fourth sample type is to be analyzed for the determination of moisture content.

The first three sample types are each to be composites constructed from nine component samples with the nine components collected from pre-selected, stratified-random locations within one of the four quadrants of the annulus. For each of these sample types, two independent composites will be constructed (each composed of an independent set of nine component samples) from each quadrant, which will each be analyzed and compared to evaluate spatial variability.

The specific locations from which component samples are to be collected from within each quadrant are to be defined by:

- dividing the quadrant up into 9 segments;

- selecting two random numbers to represent the coordinates to be sampled within each segment; and

- repeat the process nine times to obtain the coordinates for collection of the nine component samples for each composite (one component sample from within each segment of the quadrant).

Moisture content samples will not be composited. Instead (either immediately before or immediately after simulations are conducted in a source area), a single sample will be collected from the center of each quadrant of the source area and each of these will be separately packaged and sent for analysis for moisture content.

The manner in which each sample type is to be collected, prepared, labeled, and packaged is described below.

1.2.1. Procedures for collection of composite samples for determination of asbestos

As previously indicated, composites for determination of asbestos are to be constructed by combining material from nine component samples each collected from a pre-selected, random location within one of the nine segments of a particular quadrant of the annular source area.

Note, component samples for composites collected for the determination of asbestos, for composites collected for the determination of ACM content, and for composites collected for the determination of silt content are to be collected from the same locations, and the order in which the samples are collected is important. Asbestos samples are to be collected first followed by samples for ACM content with samples for silt content collected last.

Component samples are to be collected for asbestos determination as follows:

1. at each defined (random) location within each of the nine segments of a particular quadrant, the surface to be sampled (a square area that is approximately 30 cm on a side) is first to be cleared of vegetation, biological debris, stones, and any construction debris that is obviously non-ACM. Gently hand-pick these materials and remove them from the sampling area. If the area to be sampled is heavily vegetated, it may first be cleared using a scythe or other cutting tool;

2. once cleared, use a clean trowel in a reproducible manner to scrape material from a one-inch depth centered on the identified sampling location, until the trowel is sufficiently full to satisfy Step 3;

3. gently pour the material from the trowel into a clean, transfer container with a mark indicating a volume of 125 cm^3 (approximately one-half cup, English units). If the presence of a larger piece of debris, rock, or other solid object is picked up by the trowel but is too large to reasonably include within the indicated sample volume (i.e. if it comprises more than one half of the volume of the sample), remove the object, characterize it as potential ACM or non-ACM and note the modification to the sample in the field log. Also, continue filling the transfer container to replace the volume removed. If the object is not ACM, it may be discarded. If the object is ACM (or apparent ACM), it should be separately bagged, labeled, and shipped to the laboratory as an object associated with the particular sample.

   Note, ideally the transfer container can be filled with a single scoop from the trowel. If not, be careful to transfer material from the trowel to the container using a procedure that will not result in size-selective transfer. For example, do not tilt the trowel so that a particular layer on the trowel pours into the container. Rather, use a knife or spatula to divide the material in the trowel vertically and introduce all of the material from the divider forward into the container;

4. quantitatively transfer the component sample from the transfer container to a clean, pre-weighed sample container (of sufficient volume to hold the combined material) and combine all nine component samples of a particular composite for a particular quadrant into the same sample container; and

5. determine the mass (to the nearest 0.2 g), label, and prepare the sealed containers for shipment.

Importantly, it is generally unlikely that so much of a 144 square-inch area (demarcated by a template) around a selected sampling location would be comprised of rocks, construction debris, or other materials that make collection of a sample impossible. However, in the rare case the sampling is found to be impossible, the sampling location is to be moved 12 inches to the due south and the fact that the sampling location had to be moved is to be noted in the field log. In the remote possibility that sampling at this first-alternate location is also impossible, the sample location may be moved an additional 12 inches due south, as long as this second change is also noted in the field log. Such modifications may be repeated up to four times, if absolutely necessary, until a suitable location for sampling is encountered. However, any such modification of location must only be because more than half of the template area of a previous

location is impossible to sample. This same modification can also be applied to each of the other three sampling types.

1.2.2. Procedures for collection of composite samples for determination of ACM

As previously indicated, composites for determination of ACM content are to be constructed by combining material from nine component samples each collected from a pre-selected, random location within one of the segments of a particular quadrants of the annular source area. Procedures for collection of samples are described below.

Once the component sample has been collected for the composite for determination of asbestos, the component sample for determination of ACM content is to be collected from the same location in the following manner:

1. place a 30-cm (12-inch) template on the ground so that it is centered over the location from which the component sample was previously collected for the determination of asbestos;

2. using a trowel, scoop dirt from within the *entire* template to a depth of one inch and place the material in a pre-weighed (to the nearest 10 g), 5-gal bucket;

3. combine material from all nine component samples from a particular quadrant into the same, pre-weighed bucket;

4. once all the material from the components of a particular composite are combined, weigh the bucket, determine the mass of the material to the nearest 10 g and record the mass in the field log;

5. place a sieve with 1-cm (3/8ths-inch) openings over a second bucket and sieve the material from the weighted bucket into the new bucket. Gently work the material on the sieve so that the fines pass through. Then, examine the material caught on the sieve and remove all objects that are obviously not ACM (e.g. rocks or concrete construction debris). Any material left on the sieve that is potentially ACM should then be transferred quantitatively to another pre-weighed container;

6. determine the mass of the ACM from each composite to the nearest 0.2 g and record the mass in the field log. Importantly, weighing of the original material from an entire composite and the ACM from the same composite must occur within 30 minutes of each other to minimize the chance that weights will be affected by changes in moisture content;

7. once weighing of the ACM is complete, the fines from the composite will be containerized and disposed of as asbestos-contaminated waste.. The ACM shall be sealed in a plastic bag, properly labeled, and stored for possible shipment to the laboratory for analysis at a later date.

1.2.3. Procedures for collection of composite samples for determination of silt content

A minimum of 1 L (2 kg) of material is to be collected for determination of silt content. As currently planned, the material from the samples collected is to be sealed in a 1-gal Ziploc bag. Following collection of the sample for determination of ACM content, samples for silt content shall be collected by:

1. within each of the nine segments of a particular quadrant, component silt content samples are to be collected from a location immediately adjacent to and north of the square from which the sample was previously removed for determination of ACM content;

2. use a clean trowel in a reproducible manner to scrape material from a one-inch depth centered on the identified sampling location, until the trowel is sufficiently full to satisfy Step 3;

3. gently pour the material from the trowel into a clean, transfer container with a mark indicating a volume of 125 cm^3 (approximately one-half cup, English units). If the presence of a larger piece of debris, rock, or other solid object is picked up by the trowel but is too large to reasonably include within the indicated sample volume (i.e. if it comprises more than one half of the volume of the sample), remove the object and note the modification to the sample in the field log. Any such object can then be disposed of *in an appropriate manner* that will depend on whether the object is ACM. Also, continue filling the transfer container to replace the volume removed.

   Note, ideally the container indicating the sample volume can be filled from a integer number of trowel scoops (one or two). If not, be careful to transfer material from the trowel to the container using a procedure that will not result in size-selective transfer. For example, do not tilt the trowel so that a particular layer on the trowel pours into the container. Rather, use a knife or spatula to divide the material in the trowel vertically and introduce all of the material from the divider forward into the container.

4. quantitatively transfer the component sample from the transfer container to a clean, pre-weighed 1-gal Ziploc bag and combine all nine component samples of the composite for a particular quadrant into the same bag; and

5. determine the mass (to the nearest 0.2 g), label, and prepare the sealed containers for shipment.

1.2.4. Procedures for collection of samples for determination of moisture content

As previously indicated, moisture content samples are *not* composited. Rather, a single sample is to be collected from the center of each quadrant (i.e. at the midpoint of the arc representing the quadrant and the midpoint of the perpendicular, radial line that passes through the midpoint of the arc) of each source area of the runner scenario that is to be characterized and each of these four samples are to be separately weighed, packaged, labeled, and sent to the laboratory. Also, these samples are to be collected either immediately before or immediately after the actual simulations are conducted (rather than in advance as with the other sample types discussed above).

To collect samples for moisture content:

1. place a 30-cm (12-inch) template on the ground so that it is centered over the selected sampling location;

2. use a trowel to scoop dirt from within the template to a depth of one inch. The material collected is to be placed in a (pre-weighed) 1-gal, heavy gauge, Ziploc bag;

3. specifically for these samples, once filled, it is important to create an air-tight seal on the sampling container. Thus, be sure to seal the Ziploc bags completely and to test them to be sure that the seal is air tight; and

4. weigh the bag (to the nearest 0.2 g), label, and prepare the sealed containers for shipment to the laboratory.

1.3. Procedures for Characterizing Source Areas in Conjunction with Simulating Bicycling

Source areas for simulating bicycling are to be identical in shape and size to those defined for running (Section 1.2). The manner in which sampling locations are to be identified for these source areas is also identical to that defined for areas to be used to support a running simulation. However, only two (as opposed to four) types of samples are to be collected from each sampling location defined for a bicycling source area. These are:

- samples to be analyzed for the determination of silt content; and

- samples to be analyzed for the determination of moisture content.

Source areas selected for bicycling simulations are only to be evaluated for dust transport (not asbestos transport). Therefore characterization for asbestos or ACM content is superfluous.

The manner in which silt and moisture content samples are to be collected, handled, packaged, and labeled for bicycling simulation areas are identical to those described for the corresponding samples in Section 1.2.

2. Procedures for Conducting Simulations

Standard operating procedures proposed for conducting simulations of child's play, running, and bicycling are separately described in the following subsections.

2.1. Procedures for Simulating Child's Play

To assure compatibility, the design of the child's play simulation closely parallels what was originally conducted in the EPA study. Refinements have also been added, however, to assure that the data collected can be fully utilized to evaluate *all* important aspects of the modeling approach for assessment of risk (see Section 2.1.1.1).

Before beginning a particular run for the child's play simulation, the quadrants of the source area for the simulation will be numbered sequentially from one to four. Two, randomly selected, locations will also be demarcated in each quadrant and the locations in each quadrant will be labeled "a" and "b".

On the day that a particular simulation is to be conducted, a background air sampler will also be set up to collect a high-volume sample of air at a location that is immediately upwind of the source area at which simulations are to be conducted. The specific location should be chosen to be not less than 50 feet and not more than 150 feet from the source area. It should also be chosen to be upwind, based on conditions observed (and predicted) for the day in which simulations are to be conducted. A target air volume of 2,500 L is set for these samples.

To minimize potential contamination, the generators to be employed to power the high-volume samplers for collecting the upwind samples will be located a minimum of 25 feet cross-wind of the sampling stations themselves.

Importantly, the background (upwind) samples will be collected as quality control samples primarily to support corrective actions or other, independent evaluations of potential problems, if such problems become apparent based on unexpected conditions or inconsistent results from the actual studies. Otherwise, it is not anticipated that the filters collected at these locations will be analyzed.

A meteorological station will also be setup and run to record relevant conditions on days immediately prior to and during the time that the simulations are being conducted. Details of the requirements for monitoring meteorology are provided in Section 4.

The worker who will conduct the child's play simulation will don appropriate, personal protective equipment (consistent with the requirements of the Health and Safety Plan (PBS 2005). He will also be fitted with four sampling pumps and cassettes:

- the first cassette (containing an MCE filter suitable for determination of asbestos) will be secured to the worker's left lapel but hung somewhat lower so that the air is sampled from a distance that is approximately 2 feet above the ground (consistent with the elevation sampled in the EPA study);

- a second cassette (fitted with a cyclone for sampling respirable dust -- will also be secured to the same lapel and will be adjusted to sample air immediately adjacent to the location from which the first cassette is sampling air;

- a third cassette (containing an MCE filter for asbestos analysis) will be secured to the worker's right lapel and hung so that it too samples air from the same elevation as the other cassettes; and

- a fourth cassette (containing an MCE filter for asbestos analysis) will be secured to the worker's belt in the immediate vicinity of the particle monitor (see below).

The worker will also wear an automated particle sampler on his belt to obtain measurements of dust from this location that are comparable to corresponding measurements obtained during the original EPA study (see Berman 2005 – simulation report). Thus, the model to be employed is the MIE PDR 1000, which provides real-time readouts of respirable dust concentrations at one minute intervals)[2].

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[2] Prior to conducting the proposed simulations, the relative agreement between respirable dust concentrations respectively determined using the automated particle counter (the MIE PDR

Air flow rates for the asbestos cassette to be worn on the left lapel will be adjusted to collect a target volume of 90 L for an anticipated run of approximately 80 minutes. The asbestos cassette to be worn on the right lapel will be adjusted to collect a target volume of 50 L under the same conditions. It may also be prudent to conduct an initial, "dry" run with only the automated particle counter (mounted at the waist) running. This will provide an indication of the dust concentration likely to be produced with which it may be possible to refine target volumes that can be optimally loaded while minimizing the chance of overloading. The flow rate for the dust cassette is fixed by the dynamics of the cyclone.

The individual conducting the actual simulation will begin by facing north at location "a" in the first quadrant and sitting or kneeling. He will then proceed to mimic children digging in soil by using a small shovel to scoop dirt and load it into a 1gallon bucket. The manner in which dirt is loaded into the bucket need not be methodical, as children often toss dirt carelessly about during play and some of this activity should be mimicked. However, it is important that the bucket be largely filled within the space of five minutes so that it can then be dumped. Importantly, to assure that the soil disturbed during this simulation is consistent with the source material initially characterized, the soil shall be collected only from the top one-inch of soil.

As soon as one cycle is completed (i.e. as soon as the bucket is loaded and dumped once within the span of five minutes), the worker conducting the simulation will turn and face east and continue with a second cycle (loading and dumping the bucket once). He will then stand and move quickly to location "a" in Quadrant 2, where he will complete two more cycles: one facing south and the next facing west. The worker will then move to location "a" in Quadrant 3 and repeat two cycles (facing north and then east) and then move to location "a" in Quadrant 4 and repeat two cycles (facing south and then west).

The worker will then return to Quadrant 1 and position himself at location "b" and begin the entire process of completing two cycles at the "b" locations in each quadrant while rotating 90° clockwise between each cycle.

When the worker has completed the two full rounds (i.e. a total of 16 cycles, two at a time at each of two locations in each of four quadrants), the first run of this simulation will be deemed complete. Note that the time required to complete this effort should be only slightly more than 80 minutes.

1000) and using the cyclone/filter cassettes will be evaluated by generating a series of paired measurements from a series of environments with varying dust concentrations. The manner in which the comparison will be conducted is entirely analogous to that described for comparing predicted and measured respirable dust concentrations (Section 2.1.1.2).

Two more runs (identical to those described above) will be completed at the source area for child's play (for a total of three runs at each source area selected for simulating child's play). Each run should be separated in time by a minimum of an hour from the previous run. Thus, at maximum efficiency, three child's play runs can be completed at a particular source area in a little more than seven hours.

Note that simulations should be conducted in dry weather. If the scheduled day for conducting simulations is not dry, the simulations should be postponed until suitable weather prevails.

2.2. Procedures for Simulating Running

On the day that a particular simulation is to be conducted, a background air sampler will be set up to collect a high-volume sample of air at a location that is immediately upwind of the source area at which simulations are to be conducted. The specific location should be chosen to be not less than 50 feet and not more than 150 feet from the source area. It should also be chosen to be upwind, based on conditions observed (and predicted) for the day in which simulations are to be conducted. A target air volume of 2,500 L is set for these samples.

To minimize potential contamination, the generators to be employed to power the high-volume samplers for collecting the upwind samples will be located a minimum of 25 feet cross-wind of the sampling stations themselves.

Importantly, the background (upwind) samples will be collected as quality control samples primarily to support corrective actions or other, independent evaluations of potential problems, if such problems become apparent based on unexpected conditions or inconsistent results from the actual studies. Otherwise, it is not anticipated that the filters collected at these locations will be analyzed.

A meteorological station will also be setup and run to record relevant conditions on days immediately prior to and during the time that the simulations are being conducted. Details of the requirements for monitoring meteorology are provided in Section 4.

Two workers will conduct the running simulation. Each will don appropriate, personal protective equipment (consistent with the requirements of the Health and Safety Plan (PBS 2005). They will also each be fitted with four sampling pumps and cassettes:

- the first cassette (containing an MCE filter suitable for determination of asbestos) will be secured to each worker's left lapel so that the air is sampled from the immediate breathing zone of each worker;

- a second cassette (fitted with a cyclone for sampling respirable dust --) will also be secured to the same lapel and will be adjusted to sample air immediately adjacent to the location from which the first cassette is sampling air. Note, if this proves unwieldy, the dust cassette may be secured to the right lapel;

- a third cassette (containing an MCE filter for asbestos analysis) will be secured to each worker's waist on his left side; and

- a fourth cassette (fitted with a cyclone for sampling respirable dust secured to each workers waist on the right side.

Note that the purpose for collecting samples from the collar and the waist will provide two elevations from which dust concentrations can be determined, which may be compared against various models of dispersion to better evaluate overall transport of dust.

Importantly, cassettes mounted on the lapels and waists of the runners will be mounted in a manner facilitating rapid change out from one runner to the next. This is because multiple runners may be required to complete the 90 minutes of continual activity proposed for each run of these simulations.

As a first estimate, air-flow rates for the asbestos cassette to be worn on both the lapels and at the waist may be adjusted to collect a target volume of 100 L for an anticipated run of approximately 90 min. However, these may be refined for later runs, should it be possible to have the filters from the initial runs inspected to evaluate general loading. Alternately, should time and budget allow, it would be extremely useful to conduct an initial, "dry" run with only automated particle counters (mounted at the lapel and waist of each runner) to gauge the levels of dust likely to be produced. Such information would then be used to refine and optimize air volumes to be targeted for the running scenario. Note that the flow rates for all dust cassettes are fixed by the dynamics of the cyclone.

The workers conducting the actual simulation will begin by having the lead runner stand in the radial center of the source area annulus at a designated location direction from the center. The second worker (the following runner) will stand approximately 2.5 m (approximately 8 ft) behind the lead runner and he will attempt to maintain this distance over the entire course of the run.

The run will commence with the two runners (maintaining the distance between them) accelerating up to a comfortable jogging pace and then maintaining that pace as they run around the annulus for 90 minutes (or for a fixed, shorter period, if multiple runners are anticipated). A third worker will use a stop-watch to time the runner's progress around the "track" and will provide advice to help the runners maintain a constant speed. These times will also be recorded in the field log-book so that the precise speed of the runners can be determined.

If, as is likely, multiple runners will be needed to assure that the pace can be maintained for 90 minutes, pairs of runners can be changed out every 15 to 30 minutes (at some pre-defined, fixed interval) and note that longer intervals (with fewer transfers) are preferred. During change out, runners will stop at a pre-designated location around the "track" and will stop and transfer their cassettes and pumps to fresh runners who will then accelerate and continue the pace until they are changed out. For this procedure to be reasonable, however, it is important that the time required to transfer sampling equipment can be kept to a minimum. Thus, for example, the majority of such equipment may be mounted on a quick release belt (with the lapel samplers clipped on) so that only the belt needs to be transferred along with re-clipping the lapel samplers.

It may be prudent to have extra workers assist with each transfer and it will be critical to practice such transfers prior to conducting the simulations to be sure that they can be performed without problems.

As currently envisioned, the running simulation will be repeated for a total of three repetitions per source area. It will also be conducted once in an asbestos-contaminated source area and once in an area exhibiting a radically different moisture content and, potentially, silt content. The second area need not necessarily be contaminated with asbestos so that, for example, it may be possible to conduct the second simulation in Portland or another location with substantially different weather, if this is helpful. Further, if simulations are conducted in areas that are not contaminated with asbestos, pumps and cassettes required for monitoring asbestos will not be required. In such a case, runners need only wear pumps and cassettes for collection of respirable dust.

Note that simulations should be conducted in dry weather. If the scheduled day for conducting simulations is not dry, the simulations should be postponed until suitable weather prevails.

2.3. Procedures for Simulating Bicycling

As currently proposed, bicycle simulations will only be monitored for generated dust concentrations. Therefore, these simulations do not need to be conducted

on asbestos-contaminated property. What is more important is to find sites that vary substantially in moisture content and, potentially, silt content.

Although an option exists for conducting the bicycle simulation with a lead and following rider, another approach is to construct a simple cart that can be towed behind a single bicycle, which will provide a platform for mounting multiple samplers at multiple heights and off-center widths behind the lead bicycle. This is the approach proposed here for this set of simulations. A design for the proposed cart is presented in Figure A-1.

As can be seen in Figure A-1, the cart will be simple and will have places to hold samplers at two distances and at two elevations behind the bicycle. At the furthermost distance, an additional arm will allow determination of differences in dust concentrations as a function of transverse distance from the centerline of the cart.

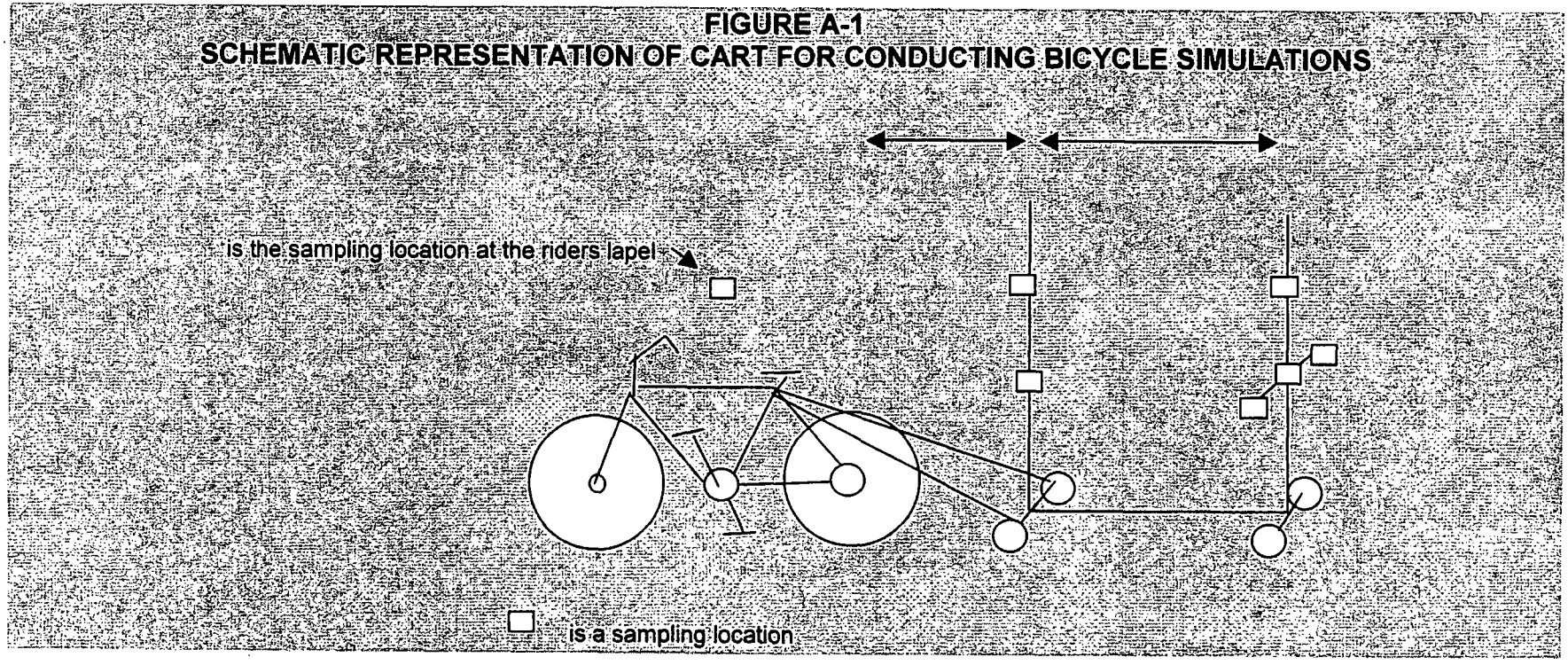
On the day that a particular simulation is to be conducted, a background air sampler will also be set up to collect background dust concentrations in air that is immediately upwind of the source area at which simulations are to be conducted. The specific location should be chosen to be not less than 50 feet and not more than 150 feet from the source. It should also be chosen to be upwind, based on conditions observed (and predicted) for the day in which simulations are to be conducted. Either a high volume sampler for respirable dust concentrations or, perhaps, an automated particle counter with direct readout may be used for this purpose.

To minimize potential contamination, the generators to be employed to power the high-volume samplers for collecting the upwind samples will be located a minimum of 25 ft cross-wind of the sampling stations themselves.

Importantly, the background (upwind) samples will be collected as quality control samples primarily to support corrective actions or other, independent evaluations of potential problems, if such problems become apparent based on unexpected conditions or inconsistent results from the actual studies. Otherwise, it is not anticipated that the filters collected at these locations will be analyzed.

A meteorological station will also be setup and run to record relevant conditions on days immediately prior to and during the time that the simulations are being conducted. Details of the requirements for monitoring meteorology are provided in Section 4.

FIGURE A-1
SCHEMATIC REPRESENTATION OF CART FOR CONDUCTING BICYCLE SIMULATIONS



D. Wayne Berman, Aeolus, Inc.

As currently proposed, only one worker will conduct the bicycle simulation. They will don appropriate, personal protective equipment (consistent with the requirements of the Health and Safety Plan (PBS 2005). Importantly, because these simulations may not be conducted in contaminated areas, respiratory protection may not be required. The rider will also be fitted with a single sampling pump and cassette (fitted with a cyclone for sampling respirable dust -- that will be secured to the rider's left lapel and will be adjusted to sample air in the immediate breathing zone of the rider. Note that this device must be easily transferred in case multiple riders are required to complete the entire bicycle run.

Up to six additional dust samplers will also be secured to the cart to be towed behind the bicycle;

- the first sampler will be mounted at the breathing zone height of a rider at a distance of about 1.5 m (5 ft) behind the rear wheel of the bicycle;
- the second sampler will be mounted at the waist height of the rider at the same 1.5 m distance behind the rear wheel;
- the third sampler will be mounted at the breathing zone height of a rider a distance of 2.5 m (approximately 8 ft) behind the first set of samplers;
- the fourth sampler will be mounted at waist height of the rider at the same 2.5 m distance; and
- potentially, two additional samplers will be mounted at this same wasit height at this same distance of 2.5 m, but they will be extended left and right from the centerline of the cart by a distance of approximately 1 m.

Note that the locations indicated above are depicted schematically in Figure A-1.

Note that the purpose for collecting the multiple samples from various heights and distances will be to provide information about the degree of dispersion that occurs for dust generated from bicycle riding. Such data may then be compared against various models of dispersion to better evaluate overall transport of dust.

Importantly, cassettes mounted on the lapels and waists of the riders will be mounted in a manner facilitating rapid change out from one rider to the next. This is because multiple riders may be required to complete the potential 120 minutes of continual activity proposed for each run of these simulations. Actually, the time for the simulation will be optimized to collect the best volume for determination of dust concentrations, given the fixed rate at which pumps will be operated to assure proper operation of the cyclones.

The worker conducting the actual simulation will begin by mounting the bicycle and accelerating to the desired speed (probably about 12 mph). A second worker will use a stop-watch to time the rider's progress around the "track" and will provide advice to help the rider maintain a constant speed. These times will also be recorded in the field log-book so that the precise speed of the rider can be determined.

If multiple riders will be needed to assure that the pace can be maintained for the required, optimal time for the simulation, riders can be changed out every 30 to 60 minutes (at some pre-defined, fixed interval) and note that longer intervals (with fewer transfers) are preferred. During change out, a rider will stop at a pre-designated location around the "track" and will transfer their cassettes and pumps to a fresh rider who will then accelerate and continue the pace until they are changed out. For this procedure to be reasonable, however, it is important that the time required to transfer sampling equipment can be kept to a minimum. Thus, for example, the majority of such equipment may be mounted on a quick release belt (with the lapel samplers clipped on) so that only the belt needs to be transferred along with re-clipping the lapel samplers.

It may be prudent to have extra workers assist with each transfer and it will be critical to practice such transfers prior to conducting the simulations to be sure that they can be performed without problems.

Note that simulations should be conducted in dry weather. If the scheduled day for conducting simulations is not dry, the simulations should be postponed until suitable weather prevails.

3. Procedures for Monitoring Exposure Concentrations

Asbestos exposure concentrations will be monitored and analyzed based on the procedures described in ISO Method 10312 (ISO 1995). Thus, samples will be collected using standard, 25 mm filter cassettes with 0.45-μm pore-size MCE filters. Samples will then be shipped to the laboratory where they will be prepared by direct transfer and analyzed using the counting rules defined in the method with the following modifications:

- a minimum of three grid specimens will be prepared from each filter and counts of all structures will be spread approximately evenly across the three grid specimens.

- total ISO structures (including short structures) will be counted at a magnification of 20,000x by scanning a sufficient number of grid openings to achieve an analytical sensitivity of 1.5×10^{-2} s/cm^3; and

- protocol structures (i.e. structures longer than 5-μm and thinner than 0.5-μm) and 7402 structures (i.e. those defined by the "B" counting rules in Appendix B, NIOSH Method 7400 Revision 2 – NIOSH 1987) will be counted at a magnification of 10,000x by scanning a sufficient number of grid openings to achieve an analytical sensitivity of $1x10^{-3}$ s/cm^3. Importantly, if based on initial dry runs, it is shown possible to collect larger volumes of air than the currently proposed target, the target analytical sensitivities may be adjusted downward accordingly. This may be especially helpful for the running simulation.

Note, depending on the specific sites selected for each simulation, these target analytical sensitivities may be adjusted. Other stopping rules may also be modified to optimize the effectiveness of analysis.

Dust exposure concentrations will be monitored using NIOSH Method 0600, Issue 3 (1998). Samples will be collected on a pre-weighed 5-μm PVC filter mounted in a filter cassette fitted with a 10-mm cyclone, attached to a personal sampling pump. The concentration of respirable particulate is then calculated based on the resulting post-sampling weight of the sample-containing filter, and based on the air volume sampled.

4. Procedures for Monitoring Meteorological Conditions

A meteorological station will be set up to monitor local conditions both in the days leading up to the simulations and during the time that the simulations are actually conducted. At a minimum, the meteorology station to be employed will provide measurements of temperature, mean wind speed for interval, peak wind speed for interval, wind direction, relative humidity, and barometric pressure and these will be determined over one-minute sampling intervals.

A HOBO Weather Station with data logger will be utilized, that contains sensors that will automatically measure the above parameters. The station is mounted on a 3-meter high tripod, that allows each sensor to be mounted at the correct height for optimal measurement accuracy. At the end of the activity, data will be downloaded in the field to a Palm handheld.

5. Discussion of Logistical Details

5.1 Sample Labeling

Each sample to be shipped for laboratory analysis will be labeled with a unique number that will include the sample site identification number, an indication of the type of sample, an indication as to whether the sample is an original sample or a composite duplicate, an indication of whether the sample is intended for air,

silt/moisture content analysis or asbestos analysis, and the date that the sample is collected. It is thus suggested that sample numbers be constructed with 11 digits as follows:

QQ-XYZ-mm-dd-yy

where:

QQ is the two digit code indicating the sampling site from which the sample was collected;

X is either A (air) or S (soil);

Y is either a 0 or a 1 indicating whether the sample is a project sample or a composite duplicate, respectively;

Z is for soil samples, and is either an A or an M indicating whether the sample is intended for asbestos or moisture/silt analysis, respectively; and

the last set of digits represents the date in standard format.

5.2 Decontamination of Field Equipment

Prior to use in the field, all sampling equipment (e.g. trowels and templates) will be decontaminated by washing with biodegradable soap, rinsing with asbestos-free water, and drying either with asbestos-free cloth rag or forced air. If forced air is used, it must be HEPA filtered to assure that it remains asbestos-free. Sampling equipment will be similarly decontaminated prior to removing it from the site.

Between collection of individual soil samples, sampling equipment may be wiped clean with a clean, asbestos-free cloth rag.

Wash and rinse water will be collected and containerized. Any disposable materials used for decontamination (e.g. rags) will be disposed with ACM waste.

5.3 Chain of Custody

The Project Coordinator's representative will manage sample handling, transport and storage with appropriate Chain-of-Custody documentation.

5.4 Documentation

The following information will be recorded for each sample collected during this project:

-the sample identifier (including the grid square number and the date that the sample was collected);

- the times that the sample were collected, general weather observations;

-the GPS location of the sample;

-any required modifications to the location initially selected for sample collection along with the reasons (i.e. the nature of any field obstructions) for needing such modification;

-any changes or modifications required to the above-indicated procedures for sample collection;

-relevant observations concerning the condition (presence of vegetation, color and condition of soil, relative apparent moisture content, etc.) of the location from which the sample is collected (to be supplemented with photographs);

-documentation of any ACM (size, nature, color, type, etc.) observed at the sample location; and

-any other, potentially relevant information concerning the conditions under which the sample is collected (e.g. any required weights or similar information).

6. Quality Control/Quality Assurance Considerations

Routine blanks and duplicates will be collected as part of this sampling effort. These include:

- Two lot blanks per filter lot;
- One sand blank per batch of elutriator samples; and
- One trip blank per sample shipment of air samples.

Note that, by careful selection and use of filters, it may be possible to reduce the total number of blanks by having some filters serve multiple purposes. Thus, for example, lot blanks and trip blanks may actually represent the same sample.

Importantly, all blanks will be analyzed at sufficient analytical sensitivity and at sufficient sensitivity for surface density to adequately cover the lowest end of the range of corresponding project sample concentrations targeted for this study.

Due to the substantial redundancy in replicate runs and duplicate splits incorporated into the design of this plan, as long as all analyses are conducted by a single laboratory, there is little need for analyzing additional duplicates, except to assist with corrective actions. Moreover, because two filters are to be collected (at different flow rates) to evaluate exposure concentrations, this obviates the need to collect additional duplicate filters that may otherwise be held and used in case a problem needs to be traced as part of a corrective action effort.

During homogenization and splitting of samples destined for elutriation, duplicate splits of every sample will be prepared and stored in case they are needed to trace problems as part of a corrective action.

Appendix B

PBS

APPENDIX B:

STANDARD OPERATING PROCEDURE FOR EVALUATING SCREENING PROCEDURES

NORTH RIDGE ESTATES
KLAMATH FALLS, OREGON

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SOP for Evaluating Screening Procedures
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STANDARD OPERATING PROCEDURE FOR EVALUATING SCREENING PROCEDURES AT THE NORTH RIDGE ESTATES SITE, KLAMATH FALLS, OREGON

D. Wayne Berman, Ph.D.
Aeolus, Inc.
July 7, 2005

This Standard Operating Procedure (SOP) was developed to guide sample collection, preparation and analysis in support of an evaluation of several candidate screening procedures proposed to supplement analysis for determination of asbestos at the North Ridge Estates Site. Procedures are defined below for selecting sampling locations for conducting screening of each location, and for collecting samples from the locations selected. This includes procedures required to support quality control (including collection of specific types of quality control samples). Procedures are also briefly defined for chain-of-custody, sample labeling, documentation requirements and decontamination of equipment. Laboratory preparation and analysis to be conducted on samples for the determination of asbestos, moisture content and silt content are also defined in a separate SOP (provided as Exhibit A).

1 SELECTION OF SAMPLING SITES AND SAMPLING LOCATIONS

Because samples are to be collected to address specific questions about specific areas of the site, sampling sites are defined opportunistically. However, once a sampling site is selected, the actual locations at each site from which samples are to be collected are to be defined using a stratified-random sampling scheme. This is to be accomplished by:

- Step 1: selecting a general site for sample collection so that it satisfies a pre-defined set of criteria;
- Step 2: selecting a specific area for sample collection from within the general site based on certain visual cues;
- Step 3: defining a sampling grid over the area selected for sampling in Step 2; and
- Step 4: identifying specific locations for sample collection by choosing such locations randomly (i.e. based on a pre-identified set of randomly selected coordinates) within each grid square of the sampling grid.

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The detailed manner in which each of the above steps is to be conducted is described below.

1.1 Selecting General Sites for Sampling Based on Pre-defined Criteria

Each sampling site is to be selected so that it satisfies the corresponding set of criteria described in the last column of Table A-1. Table A-1 is an overall summary of the proposed sampling scheme.

In Table A-1, the first column indicates a number assigned to each sampling site. The second and third columns indicate the nature of the analyses tentatively assigned to each of the samples collected from each sampling site. In these columns, "EA" means extended analysis, "R" means routine analysis, and "I" means full ISO analysis. These are defined in the SOP for laboratory work (Exhibit A). Note that these may change pending observations from field and laboratory work as the sampling progresses.

The fourth column of Table A-1 indicates the nature of quality control samples to be collected within each sampling site. In this column, "CD" means a composite duplicate and "A" means an ACM characterization duplicate. The nature of each such sample is defined below (Section 3.0). Note that this list should be considered tentative and may change pending observations from field and laboratory work as the sampling progresses.

The fifth and six columns of Table A-1 indicate, respectively, whether a sampling site is on a Respondent-controlled parcel and the specific names of the parcels on which each sampling site is located. The seventh column of the table indicates the types of facilities that may have historically existed in the vicinity of the proposed sampling site.

The last column of Table A-1 describes the detailed criteria that need to be satisfied for locating the sampling grid within each of the sampling sites identified.

1.2 Selecting Areas for Sampling at Each Sampling Site Based on Visual Cues

Once a general sampling site is selected so that it satisfies one of the sets of criteria listed in Table A-1, the specific area within the site to be sampled shall be selected based on visual cues. Specifically, the area is to be selected based on a visual estimate of the concentration of ACM observed over the surface of the sampling site. A specific procedure has been defined for estimating the concentration of ACM in an area to determine its suitability for sampling and this procedure is described below. Because the procedure must first be tested and calibrated in the field, a protocol is also defined for field calibration of the procedure.

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1.2.1 Procedure for visually estimating ACM content

Stand at one edge of the candidate area for sampling and slowly walk 10 paces (about 30 ft) in one direction. As walking proceeds, count all pieces of likely ACM visible within 5 ft on either side of the path being walked. Record the number of ACM pieces observed in the field log. A qualitative statement should also be recorded regarding the relative sizes and types of the ACM pieces that are observed.

Note that, although this procedure is designed to be relatively quick and simple (so that excessive time should not be spent assuring that it is completed precisely as intended), sufficient time should be spent completing the procedure to maximize the chance of reasonably observing all ACM along the traverse and to reasonably minimize the chance of double counting.

1.2.2 Calibrating the procedure for visually estimating ACM content

To calibrate:

1. go to a location where "high" concentrations of surface ACM are known to currently exist at the site (e.g. the areas where the child's play simulation or the rototilling simulation were conducted by EPA) and conduct the procedure three times starting in different locations around the area and walking in different directions for each traverse. Note, limited overlap of traverses (if they happen to cross) is not a problem. Record the number of ACM pieces observed for each of the three traverses;

2. go to a location where "moderate" (as opposed to "high") concentrations of surface ACM are known to currently exist at the site (e.g. the areas between the warehouse and the road to the south or the area to the north of the West house where resurfacing was noticed) and conduct the procedure three times starting in different locations around the area (or use different areas) and walking in different directions for each traverse. Record the number of ACM pieces observed for each of the three traverses;

3. go to a location where "low" concentrations of surface ACM are known to currently exist at the site (e.g. the areas in the front yards of Winn, Villa, or Lee where resurfacing material has lately been observed) and conduct the procedure three times either starting in different locations in one area (or using different areas

among those listed) and walking in different directions for each traverse. Record the number of ACM pieces observed for each of the three traverses[1];

4. the range of counts observed in these three areas will be qualitatively compared to gauge the extent of variation within each type of area and the relative values between each type of area. It is hoped that the variation between the high and low areas will be substantially greater than the variation observed within these areas. If this is true, this procedure can be used to quickly and simply determine the relative level of ACM contamination at the surface of candidate areas for sampling.

1.2.3 Qualitative evaluation to select areas for sampling

Use the procedure defined above (Section 1.2.1) to provide a qualitative indication of the relative concentration of ACM in an area tentatively selected for sampling within a sampling site. Report in the field log whether the goal of the evaluation is to identify a site with high, medium, or low concentrations of ACM and whether that goal appears to have been achieved. This procedure can thus be used to assure that the sites that are ultimately sampled exhibit a broad range of ACM concentrations in surface material.

In addition, the procedure will be used to qualitatively characterize ACM concentrations in each area finally selected for sampling. Once an area is selected and the sampling grid is demarcated (Section 1.3), conduct two traverses using the procedure in Section 1.2.1 starting on two different edges of the sampling grid and walking in two different directions(e.g. first East to West and then North to South). Record the counts from each traverse in the field log.

1.3 Defining a Sampling Grid in an Area Selected for Sampling

In each area to be sampled, lay out a sampling grid that is 50 ft on each side and that is divided into four grid squares (quadrant) that are each 25 ft by 25 ft. Note that, in some cases, the size and shape of the sampling grid may need to be adjusted to assure that the area to be sampled adequately reflects the selected conditions.

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1 It is important *not* to use the flags that may have been placed at the site as visual markers for ACM. Each ACM piece *itself* must actually be seen by the individual conducting the traverse. For this reason, if portions of these areas can be found at which flags have not been placed, traverses in these other areas may be preferable to conducting the traverses in areas where flags have been placed to mark ACM.

1.4 Identifying Specific Locations for Sample Collection

To prepare for sampling within a particular sampling grid, mark off the location in the center of the overall sampling grid (at the vertex where the four grid squares touch). Also mark a randomly selected sampling location within each of the four grid squares.

Note, if the particular sampling site being gridded is also selected for collection of a composite duplicate (see Table A-1), a second set of random locations (one from within each grid square) that is independent of the first set will also need to be marked.

2 SAMPLE COLLECTION PROCEDURES

Three types of samples are to be collected from each sampling location (from each of two depths):

-the first sample type is to be analyzed for the determination of moisture content and silt content;

-the second sample type is to be analyzed for the determination of asbestos content; and

-the third sample type is to be analyzed on site for the determination of ACM content.

Each selected sampling location (identified as defined in Section 1), is to serve as the center of a 50 ft by 50 ft sampling grid, which is to be further divided into four quadrant grid squares that are each 25 ft on a side (Section 1.3). Grab samples for determination of moisture and silt content are to be collected from the center of the overall sampling *grid*. Samples to be collected for determination of asbestos content are to be composites constructed from four component samples with one component collected from a pre-selected, random location from within each of the four grid squares (quadrants) of the sampling grid. Similarly, samples to be collected for the determination of ACM content are also to be composites constructed from four component samples that are each collected from the same pre-selected locations within each grid square from which the asbestos component samples are to be collected.

One surface and one sub-surface sample of each type shall be collected from each sampling location. The sub-surface grab samples for moisture and silt content shall be collected from a pre-determined depth below and in the same location as that from which the surface sample is collected. Similarly, the sub-surface composites for both the determination of asbestos and the determination of ACM content shall be constructed from

a set of four component samples (one from each quadrant of the four-square sampling grid) that are collected at a pre-defined depth below and in the same location as that from which the component samples are collected for construction of the surface composites.

The manner in which each sample type is to be collected, prepared, labeled, and packaged is described below.

2.1 Procedure for Collection of Grab Samples for Determination of Moisture and Silt Content

A minimum of 1 L (2 kg) of material is to be collected for determination of moisture and silt content. As currently planned, the material from the samples collected is to be sealed in a 1-gal Ziploc bag. Surface samples shall be collected by:

1. placing a 12-inch template on the ground so that it is centered over the selected sampling location;

2. using a trowel to scoop dirt from within the template to a depth of one inch. The material collected is to be placed in a (pre-weighed) 1-gal Ziploc bag;

3. Specifically for these samples, once filled, it is important to create an air-tight seal on the sampling container. Thus, be sure to seal the Ziploc bags completely and to test them to be sure that the seal is air-tight.

4. weigh (to the nearest 0.2 g), label, and prepare the sealed containers for shipment to the laboratory.

Importantly, it is generally unlikely that so much of a 144 square-inch area (demarcated by the template) around a selected sampling location would be comprised of rocks, construction debris, or other materials that make collection of a sample impossible. However, in the rare case the sampling is found to be impossible, the sampling location is to be moved 12 inches to the due south and the fact that the sampling location had to be moved is to be noted in the field log. In the remote possibility that sampling at this first-alternate location is also impossible, the sample location may be moved an additional 12-inches due south, as long as this second change is also noted in the field log. Such modifications may be repeated up to four times, if absolutely necessary, until a suitable location for sampling is encountered. However, any such modification of location must only be because more than half of the template area of a previous location is impossible to sample.

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Sub-surface grab samples are to be collected by:

1. using a clean post-hole digger to excavate an approximately 4-inch diameter hole centered over the sampling location[2];

2. advance the hole with the digger until a depth of approximately 1.5 ft is achieved;

3. the scoop that is collected between 1.5 ft and 2 ft is to serve as the sub-surface grab sample for determination of moisture and silt. Note that the amount of dirt collected in a six-inch interval within the clamshell jaws of the post-hole digger should be sufficient to just fill a 1 L sample container. If it is not, soil may need to be combined from more than one "scoop." In either case, it is important to collect and seal this sample expeditiously as the moisture content of sub-surface soil may not be in equilibrium with the air. Note that it is acceptable to seal the sample in a 1-gal Ziploc bag. Record the depth interval from which the sample is collected in the field log;

4. seal the sample container. As with the surface samples for determination of moisture and silt, it is important that the lid seal on the sampling container for this sub-surface sample be air-tight. The same procedure that is used for the surface sample to assure such a seal should also be employed for this sample;

5. weigh (to the nearest 0.2 g), label, and prepare the sealed containers for shipment; and

6. be sure to backfill the hole following sample collection to eliminate the possibility of any tripping hazard.

Because the nature of the sub-surface at any particular sampling location is not currently known, the following contingencies should be followed, if it proves impossible to collect samples in the precise manner indicated above:

- if, after successfully collecting the surface sample, the post-hole digger cannot be advanced to the pre-defined depth of two ft to complete collection of the sub-surface sample, the reason that sampling is precluded needs to be examined. Most likely, either a large piece of construction debris or the natural, local hard pan will have been encountered. If construction debris is encountered, a new sampling

2 Note that a large post-hole digger that is capable of creating a six-inch diameter hole may also be employed to collect sub-surface samples. In this latter case, however, samples should be collected from the depth interval between 21 and 24 inches (rather than the interval between 18 and 24 inches).

location (for the sub-surface sample) may be selected by moving the selected location sequentially 12 inches to the south until a sample can be obtained from the defined depth. Up to four alternate locations may be tried until it is decided that collection of the sub-surface sample is not possible. Any and all changes in location (or, ultimately, the reason for failure to obtain a sub-surface sample) should be noted in the field log;

- if a sub-surface sample cannot be collected from the pre-defined depth due to encountering natural hard pan, the sub-surface sample shall be collected from the deepest interval (immediately above the hard pan) from which a sample can be collected and the depth from which the sample is collected (along with the reason for collecting the sample from this depth) shall be recorded in the field log.

2.2 Procedure for Collection of Composite Samples for Determination of Asbestos

As previously indicated, composites for determination of asbestos are to be constructed by combining material from four component samples, each collected from a pre-selected, random location within one of the four grid squares (quadrants) of the sampling grids. Procedures for collection of surface and sub-surface samples are both described below.

Collection of surface samples for the determination of asbestos

Because component samples for composites collected for the determination of asbestos and composites collected for the determination of ACM content are to be collected from the same location, for surface samples, asbestos samples are to be collected first.

Component surface samples are to be collected as follows:

1. at each defined (random) location within each of the four grid squares, the surface to be sampled (a square area that is approximately 1 ft on a side) is first to be cleared of vegetation, biological debris, stones, and any construction debris that is obviously non-ACM. Gently hand-pick these materials and remove them from the sampling area. If the area to be sampled is heavily vegetated, it may first be cleared using a scythe or other cutting tool;

2. once cleared, use a clean trowel in a reproducible manner to scrape material from a one-inch depth centered on the identified sampling location, until the trowel is sufficiently full to satisfy Step 3;

3. gently pour the material from the trowel into a clean container with a mark indicating a volume of 125 cm^3 (approximately one-half cup, English units)[3]. If the presence of a large piece of debris, rock, or other solid object is picked up by the trowel but is too large to reasonably include within the indicated sample volume (i.e. if it comprises more than one half of the volume of the sample), remove the object, characterize it as potential ACM or non ACM and note the modification to the sample in the field log. Also, continue filling the sample container to replace the volume removed. If the object is not ACM, it may be discarded. It the object is ACM, it should be separately bagged, labeled, and shipped to the laboratory as an object associated with the particular sample. Note, be sure that the container indicating the sample volume can be filled from a single trowel scoop;

4. quantitatively transfer the component sample from the container indicating the sample volume to a clean, pre-weighed sample container and combine all four component samples of a particular composite into the same sample container; and

5. weigh (to the nearest 0.2 g), label, and prepare the sealed containers for shipment.

Collection of sub-surface samples for the determination of asbestos.

Due to the manner of their collection, sub-surface component samples for composites collected for the determination of asbestos must be collected following (or concurrently with) components for composites collected for the determination of ACM. This is different than what is required for surface samples.

Collect each sub-surface component that is used to support construction of a composite for determination of asbestos from the hole excavated (as described below, Section 2.3) to extract samples for determination of ACM content. Sub-surface components used to support construction of composites for determination of asbestos are to be collected from a location that is 3 inches above the bottom of the hole previously excavated in the following manner:

1. using a spoon, credit card, or other clean, rigid object, scrape material from around the circumference of the hole at an elevation that is 3-inches above the bottom of the hole. Scrape so that the material is collected into a clean container with a 125 cm^3 (approximately one-half cup, English units) volume demarcated. If the

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3 Note that, at sampling sites also noted in Table 1 as locations for collecting duplicate samples for ACM characterization (denoted as "A" in Column 4 of Table 1), it is required that the volume of sample to be collected for determination of asbestos be doubled to 250 cm^3 (approximately one cup, English units). See Section 3 below.

presence of a large piece of debris, rock, or other solid object is picked up in this process, but it is too large to reasonably include within the indicated sample volume (i.e. if it comprises more than one half of the volume of the sample), remove the object, characterize it as potential ACM or non ACM and note the modification to the sample in the field log. If the object is not ACM, it may be discarded. It the object is ACM, it should be separately bagged, labeled, and shipped to the laboratory as an object associated with the particular sample. Also complete filling the sample container to replace the volume removed;

2. quantitatively transfer the component sample from the container indicating the sample volume to a clean, pre-weighed sample container and combine all four component samples of a particular composite into the same sample container; and

3. weigh (to the nearest 0.2 g), label, and prepare the sealed containers for shipment to the laboratory.

2.3 Procedure for Collection of Composite Samples for Determination of ACM Content

As previously indicated, composites for determination of ACM content are to be constructed by combining material from four component samples each collected from a pre-selected, random location within one of the four grid squares (quadrants) of the sampling grids. Procedures for collection of surface and sub-surface samples are both described below.

Collection of surface samples for the determination of ACM content

As previously indicated, because component samples for composites collected for the determination of asbestos and composites collected for the determination of ACM content are to be collected from the same location, for surface samples, asbestos samples are to be collected first.

Once the component, surface sample has been collected for the composite for determination of asbestos, the component, surface sample for determination of ACM content is to be collected from the same location in the following manner:

1. place a 12-inch template on the ground so that it is centered over the location from which the component sample was previously collected for the determination of asbestos;

2. using a trowel, scoop dirt from within the *entire* template to a depth of one inch and place the material in a pre-weighed (to the nearest 10 g), 5-gal bucket;

3. combine material from all four component samples into the same, pre-weighed bucket;

4. once all the material from the components of a particular composite are combined, weigh the bucket, determine the mass of the material to the nearest 10 g and record the mass in the field log;

5. place a sieve with 3/8ths-inch (1-cm) openings over a second bucket and sieve the material from the weighed bucket into the new bucket. Gently work the material on the sieve so that the fines pass through. Then, examine the material caught on the sieve and remove all objects that are obviously not ACM (e.g. rocks or concrete construction debris). Any material left on the sieve that is potentially ACM should then be transferred quantitatively to another pre-weighed container;

6. determine the mass of the ACM from each composite to the nearest 0.2 g and record the mass in the field log. Importantly, weighing of the original material from an entire composite and the ACM from the same composite must occur within 30 minutes of each other to minimize the chance that weights will be affected by changes in moisture content;

7. once weighing of the ACM is complete, both the original material from the composite and the ACM from the composite shall be containerized and disposed as asbestos-containing waste.

Collection of sub-surface samples for the determination of ACM content

As previously indicated, due to the manner of their collection, sub-surface component samples for composites collected for the determination of asbestos must be collected following (or concurrently with) components for composites collected for the determination of ACM. This is different than what is required for surface samples.

Sub-surface samples for determination of ACM content are to be collected in the same location from which surface samples were collected in the following manner:

1. using a clean post-hole digger, excavate an approximately 4-inch diameter hole centered on the defined sampling location[4];

2. advance the hole with the digger until a depth of approximately 1 ft is achieved;

3. the scoop(s) that is (are) collected between 1 ft and 2 ft is to serve as the sub-surface sample for determination of ACM content. Place the material collected from this interval in a pre-weighed (to the nearest 10 g), 5-gal bucket. Either at this point or, certainly before the sampling hole is backfilled, collect the sub-sample required to support construction of the sub-surface composite for determination of asbestos in the manner defined above (Section 2.2). Especially if the holes are found to be unstable, it may be prudent to collect this sub-sample from each hole immediately following extraction of the component sample for construction of the composite for the determination of ACM content;

4. combine the material from all four component samples in the same, pre-weighed bucket;

5. once all the material from the components of a particular composite are combined, weigh the bucket, determine the mass of the material to the nearest 10 g, and record the mass in the field log;

6. place a sieve with 3/8ths-inch (1-cm) openings over a second bucket and sieve the material from the weighed bucket into the new bucket. Gently work the material on the sieve so that the fines pass through. Then, examine the material caught on the sieve and remove all objects that are obviously not composed of ACM (e.g. rocks or concrete construction debris). Any material left on the sieve that is potentially composed of ACM should then be transferred quantitatively to another pre-weighed container;

7. determine the mass of the ACM from each composite to the nearest 0.2 g and record the mass in the field log. Importantly, weighing of the original material from the entire composite and the ACM from the same composite must occur within 30 minutes of each other to minimize the chance that weights will be affected by changes in moisture content;

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4 Note that a large post-hole digger that is capable of creating a six-inch diameter hole may also be employed to collect sub-surface samples. In this latter case, however, samples should be collected from the six-inch depth interval between 18 and 24 inches (rather than the 12-inch interval between 12 and 24 inches). These intervals are different than those noted for collection of grab samples for moisture and silt content.

8. once weighing of the ACM is complete, both the original material from the composite and the ACM from the composite shall be containerized and disposed as asbestos-containing waste;and

9. after sample collection is complete (for both determination of asbestos and ACM content), backfill all holes to eliminate any potential tripping hazard.

Because the nature of the sub-surface at any particular sampling location is not currently known, the following contingencies should be followed, if it proves impossible to collect samples in the precise manner indicated above. Note that this procedure varies somewhat from the procedure previously defined for grab samples:

- if, after successfully collecting the surface sample, the post-hole digger cannot be advanced to the pre-defined depth of two ft to complete collection of the sub-surface sample, the reason that sampling is precluded needs to be examined. Most likely, either a large piece of construction debris or the natural, local hard pan will have been encountered. If construction debris is encountered, a new sampling location (for the sub-surface sample) may be selected by moving the selected location sequentially 12 inches toward the center of the sampling grid until a sample can be obtained from the defined depth. Up to four alternate locations (one in each direction directly surrounding the original sampling location) may be attempted. If a sample can still not be collected, see if a suitable location for sample collection can be identified by moving slightly greater distances in any of these directions (or directions in between). All reasonable efforts should be made to collect a sample. Only if no place within 5 ft from the original sampling location (in any direction) is found to be adequate for sampling should it be decided that collection of the sub-surface sample is not possible. Any and all changes in location (or, ultimately, the reason for failure to obtain a sub-surface sample) should be noted in the field log;

- if a sub-surface sample cannot be collected from the pre-defined depth due to encountering natural hard pan, the sub-surface sample shall be collected from the deepest interval (immediately above the hard pan) from which a sample can be collected and the depth from which the sample is collected (along with the reason for collecting the sample from this depth) shall be recorded in the field log.

3 QUALITY CONTROL SAMPLING

Material for two types of quality control (QC) samples needs to collected in the field, in addition to the project samples already discussed. These are composite duplicates (identified as "CD" in Table B-1) and ACM characterization duplicates (identified as "A" in

Table B-1).

Composite Duplicates. At all sampling sites listed in Table B-1 from which a composite duplicate is to be collected, a second set of four randomly selected sampling locations (one within each of the four grid squares of the sampling grid) needs to be identified. These locations need to be selected in addition to (and in a manner assuring that they are entirely independent of) the locations originally identified at the same sampling site for the project sample.

This second set of random sampling locations is then to be treated as it is for a unique sampling site. Thus, both a set of surface and sub-surface composite samples for the determination of asbestos need to be constructed from samples collected at these locations (for packaging, labeling, and shipment to the laboratory) and a set of surface and sub-surface composite samples for the determination of ACM content need to be collected and processed in the field.

ACM Characterization Duplicates. At all sampling sites listed in Table B-1 from which an ACM characterization duplicate is required, the sample volumes for both the surface and sub-surface samples to be collected for determination of asbestos need to be doubled (from 125 cm^3/component sample to 250 cm^3/component sample).

4 OTHER PROCEDURES

Following are procedures to be followed for sample labeling, documentation, decontamination, and chain-of-custody.

4.1 Sample Labeling

Each sample to be shipped for laboratory analysis will be labeled with a unique number that will include the sample site identification number, an indication as to whether the sample is a surface or sub-surface sample, an indication as to whether the sample is an original sample or a composite duplicate, an indication of whether the sample is intended for silt/moisture content analysis or asbestos analysis, and the date that the sample is collected. It is thus suggested that sample numbers be constructed with 11 digits as follows:

QQ-XYZ-mm-dd-yy

where:

QQ is the two-digit code indicating the sampling site from which the sample was collected;

X is either an S or a D indicating a surface or sub-surface (deep) sample;

Y is either a 0 or a 1 indicating whether the sample is a project sample or a composite duplicate, respectively;

Z is either an A or an M indicating whether the sample is intended for asbestos or moisture/silt analysis, respectively; and

the last set of digits represents the date in standard format.

4.2 Decontamination of Field Equipment

Prior to use in the field, all sampling equipment (e.g. trowels and templates) will be decontaminated by washing with biodegradable soap, rinsing with asbestos-free water, and drying either with asbestos-free cloth rag or forced air. If forced air is used, it must be HEPA filtered to assure that it remains asbestos-free. Sampling equipment will be similarly decontaminated prior to removing it from the site.

Between collection of individual soil samples, sampling equipment may be wiped clean with a clean, asbestos-free cloth rag.

Wash and rinse water will be collected and containerized, and handled with the contractor's decontamination unit wastewater. Any disposable materials used for decontamination (e.g. rags) will be disposed with ACM waste.

4.3 Chain of Custody

The Project Coordinator's representative will manage sample handling, transport and storage with appropriate Chain-of-Custody documentation.

4.4 Documentation

Documentation. The following information will be recorded for each soil sample collected during this project:

-the sample identifier (including the grid square number and the date that the sample was collected);

-the count of ACM components observed during initial characterization of the area to be sampled (if used to select the area sampled) and the target level of contamination (high, medium, low, or ND) for the site;

-the counts of ACM components observed during each of the two traverses used to characterize ACM content of the surface within the sampling grid demarcated for sampling;

-the times that the sample were collected;

-the GPS location of the sample;

-any required modifications to the location initially selected for sample collection along with the reasons (i.e. the nature of any field obstructions) for needing such modification;

-any changes or modifications required to the above-indicated procedures for sample collection;

-relevant observations concerning the condition (presence of vegetation, color and condition of soil, relative apparent moisture content, etc.) of the location from which the sample is collected (to be supplemented with photographs);

-documentation of any ACM (size, nature, color, type, etc.) observed at the sample location; and

-any other, potentially relevant information concerning the conditions under which the sample is collected (e.g. any required weights or similar information).

5 REFERENCES

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Appendix B
SOP for Evaluating Screening Procedures
North Ridge Estates, Klamath Falls, Oregon

Berman, D.W. and Kolk, A.J. *Superfund Method for the Determination of Asbestos in Soils and Bulk Materials.* Prepared for the Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency. EPA 540-R-97-028. 1997.

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Appendix B
SOP for Evaluating Screening Procedures
North Ridge Estates, Klamath Falls, Oregon

TABLE B-1

TENTATIVE LIST OF SAMPLING SITES FOR THE SPRING, 2005 FIELD SAMPLING EVENT AT THE NORTH RIDGE ESTATES SITE, KLAMATH FALLS, C

Location Number	Type of Analysis Shallow[a]	Type of Analysis Deep[a]	Quality Control Samples[b]	Category of Property	Property	Focus	Likely Asbestos Type[c] Amph	Likely Asbestos Type[c] Chry	Sampling Site Criteria[d]
1	EA,I	EA,I	CD,A		(b) (6)	Steam Plant	H	H	The area on the (b) t property within the footprint of the former heating plant
2	EA,I	R,I				No History	ND	ND	The NW portion of (b) (6) away from all footprints
3[e]	EA,I	EA,I	A	MBK		Cornett Hall	H	H	The area within the hole in the Cornett Hall Foundation in the S Center
4[f]	EA,I	EA,I	CD			Cornett Hall	H	H	The area to the immediate S of the Cornett Hall foundation between the foundation and the road
5	EA,I	EA,I	CD,A			Foundry	M	H	The area immediately to the NE of the (b) (6) house within the footprint of the old foundry
5a	EA,I	EA,I	CD,A			Foundry	M	H	The area to the N of the (b) (6) property and NE of the Cornett Hall within the footprint of the old
6	EA,I	EA,I				Nickerson	ND	M	The SW portion of the (b) (6) Property over the footprint of the former Nickerson Hall
7	EA,I	EA,I				Nickerson	U	H	The area across the road to the S of the center of the Cornett Foundation among the rubble from (b)
8	R	R				Med Facility	U	M	The (b) property between the house and the road over the location of the former medical facility clos
9	R	R				Mtg Hall	ND	M	The (b) property between the house and the road over the location of the former hall.
10	R	R	CD,A			Parad Grnds	ND	ND	The SW half of the (b) property
11	EA,I	EA,I				Steam Pipe	U	M	The area around the (b) house and between the garage and the road over the footprint of the forme
12	R	R		MBK		T-1	U	U	The area of the West Property near the road over the footprint of the former T-1 building
13	EA,I	R,I	A			Theater	U	M	The area on (b) around the footprint of the old theater
14	R	R				Tau Mu	ND	L	The central portion of the (b) property
15	R	R		MBK?		No History	ND	ND	The SE corner of the (b) property
16	R,I	EA,I		MBK?		Gymnasium	U	M	The portion of the (b) Property over the footprint of the old Gymnasium
17	R	R		MBK		Fire House	ND	M	The MBK E property around the footprint of the old fire house
18	R,I	EA,I				Admin Bldg	ND	M	The (b) property to the NE of the house over the footprint of the former admin building
19	R	R				Barracks	ND	M	The NE portion of the (b) property over the footprint of the former barracks
20	R	R		MBK		Barracks	ND	M	The SW portions of MBK C, away from the areas indicated above
21	EA,I	EA,I	CD,A	MBK		Inknown Bldg	H	H	The area to the west of the location used for the rototilling simulation, where the high temperature brick
22	R	R		MBK		Barracks	ND	M	The SW portions of MBK B, away from the areas indicated above
23	R	R	A	MBK		Inknown Bldg	H	H	The hottest observed location from within the area used for simulating rototilling
24	EA,I	EA,I		MBK		Barracks	ND	H	The hottest observed location from within the area used for simulating child's play
25	R	R	A			Barracks	ND	H	The (b) property over the footprints of the former bildings (except for the NE corners nea (b)
26	EA,I	R,I	A			Barracks	ND	M	The area between the house and the road on the (b) property within the footprints of the old buildings
27	R,I	EA,I	CD,A			Barracks	ND	M	The area between the house and the road on the (b) property within the footprints of the old buildings
28	R	R				Barracks	ND	M	The area between the house and the road on the (b) property within the footprints of the old buildings
29	R	R				Barracks	ND	H	The area E of the (b) house corresponding to the footprint of the historical building between the house
30	R	R	CD,A			Barracks	ND	H	The area between the (b) house and the road within the footprint of the former building closest to the
31	R	R				Cafeteria	ND	M	The S and SE portion of the (b) property over the footrpint of the former cafeteria
32	R	R				Maint. Shp	ND	M	The SE portion of the (b) property around the old foundations
33	R	R				No History	ND	ND	The area of the (b) property to the N and W of the house
34	EA,I	EA,I				Steam Pipe	U	M	The (b) property in the immediate area where the steampipe was removed

Notes:

[a] These represent the types of analyses tentative scheduled for the shallow and deep composite samples from each sampling site. Importantly, this list is tentative and is subject to chai pending the outcome of laboratory and field results. In these columns: "EA" means extended analysis; "R" means standard analysis; and "I" means ISO analysis.

[b] These represent the types of quality control samples to be collected. Note that the specific sites from which each type of sample is to be collected is tentative and may change pending results from earlier laboratory and field observations. In this column: "CD" means composite duplicate, "A" means ACM characterization duplicate.

[c] These columns represent a guess at the types of asbestos that might be encountered at each sampling site and a preliminary indication of the relative concentrations.

[d] This column indicates the specific criteria to be satisfied in selecting each sampling site.

[e] At this location, the sampling grid is to be reduced in size to fit within the boundaries of the hole in the foundation.

[f] At this location, the shape of the sampling grid is to be altered to fit within the strip of land between the Cornett Hall foundation and the gravel of the old road.

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APPENDIX B
EXHIBIT A

STANDARD OPERATING PROCEDURE FOR INITIAL SAMPLE PREPARATION AND ANALYSIS TO SUPPORT EVALUATION OF SCREENING PROCEDURES AT THE NORTH RIDGE ESTATES SITE, KLAMATH FALLS, OREGON

D. Wayne Berman
May 20, 2005

The following types of samples will have been received from the field:

- samples collected for determination of silt and moisture content; and
- samples collected for determination of asbestos content.

The processing required for initial preparation of these samples differs so that procedures are described separately for each type of sample below.

Note that portions of this procedure should be considered as "test" procedures and that part of the objectives of this portion of the initial phase of the RI is to evaluate the efficacy of these test procedures.

1. Initial Preparation for Samples Collected for Determination of Asbestos

Field samples collected for asbestos analyses are approximately 1 to 2 kg in mass and will not have been homogenized or sieved prior to shipment from the field. Therefore, they must be homogenized and sieved prior to splitting.

Two kinds of samples will have been received from the field: Standard Samples and ACM Characterization Duplicates. Because the procedures to be used for initial preparation of each of these kinds of samples differs, they are separately described below.

1.1. Initial Preparation for Standard Samples

Standard samples (which will be received from the field with a volume of approximately 500 cm^3) need to be sieved, homogenized, and split per the procedures described in Chapter 8 of the Superfund Method (Berman and Kolk 1997), as described briefly below.

1.1.1. Sample sieving

Prior to sieving, the mass of each sample shall be determined to the nearest 0.2 g. The sample shall then be sieved through a screen with $3/8^{th}$-inch (1 cm) openings.

Note that, because it is only the relative masses of the sample fractions that are important in this case, it is *NOT* necessary to adjust the moisture content (by drying) of these samples prior to determination of mass while conducting this procedure. As long as the entire procedure described here for sieving is completed expeditiously, changes in moisture content should not be important. At worst, they will be considered as potential process losses between the mass determination of the initial sample and the mass determination of the final coarse and fine fractions.

During sieving, be sure to manipulate the sample on the screen with gloved hands to maximize the amount of fine material that passes through the sieve. Further, any material caught on the screen that appears to be ACM shall be cut or broken until it too passes through the screen.

Once all fine material and all ACM has passed through the screen, the mass of both the coarse and fine fractions shall both be determined to the nearest 0.2 g. Record all masses in an appropriate logbook along with any pertinent observations concerning the sample and/or any modifications required to this procedure.

Once the mass of the coarse fraction has been determined, it shall be disposed as asbestos-containing waste.. The fine fraction then needs to be homogenized and split.

1.1.2. Homogenization

Homogenization shall be performed per the procedure described in Chapter 8 of the Superfund Method (Berman and Kolk 1997). Briefly, samples are to be homogenized by splitting them using a riffle splitter and recombining the resulting splits. The process needs to be repeated a minimum of five times[1] before the sample can be considered to be sufficiently homogeneous to support actual splitting.

To assure adequate homogenization, it is important to precisely follow the instructions for use of the riffle splitter in all details. Thus, for example, it is important to spread the sample to be split evenly across the bottom of a splitter pan prior to introducing it to the top of the splitter. It is also important to introduce the sample into the splitter by holding the near lip of the pan containing the sample against the near lip of the splitter and gently rotating the pan about the axis created by these lips until the sample slides smoothly and evenly into the throat of the riffle splitter along the entire length of the splitter.

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[1] Although the Superfund Method specifies a minimum of seven times to achieve adequate homogenization, the number of required passes has been reduced to five in this SOP due to the much smaller volume of sample being processed.

Note that samples received for this study will likely be sufficiently dry that they will not need further drying before homogenization and splitting. Partial drying is permissible, however, if it will facilitate clean homogenization and splitting by minimizing the amount of sampled material that may otherwise stick to the equipment. At the same time, samples should not be overly dry so that dust generation becomes a problem. Alternatively, if samples received from the field are sufficiently dry to generate substantial visible dust during homogenization and splitting, they may be misted with water to curtail such dust generation during these operations.

1.1.3. Sample splitting

Once a sample has been adequately homogenized (per the procedure described above), it can be split to produce aliquots suitable for analysis.

Samples should be split until four equivalent aliquots are created that each contain a mass between 50 and 80 g (approximately 25 to 40 cm^3). Note that, although the permissible final mass for these aliquots can fall anywhere within the range indicated, it is expected that careful splitting will produce four quadruplicate aliquots exhibiting masses that differ by no more than 10% from each other.

Of the four equivalent aliquots created by this procedure, the first should be considered as a project sample and labeled as such. The second of these aliquots should be labeled as a duplicate for archiving. The remaining two aliquots should then be labeled in a manner making it impossible to determine their relationship to the project sample (or to each other).

The nature of each aliquot and its corresponding label shall be entered into an appropriate logbook. A key shall also be provided to Aeolus, Inc. to indicate the actual nature of each aliquot and the label that has been assigned to it.

Specific instructions shall be provided on the handling of these remaining two aliquots.

1.2. Initial Preparation for ACM Characterization Duplicates

ACM Characterization Duplicates (received from the field with a volume of approximately 1,000 cm^3) will be sieved, homogenized, and split per the procedures described in Chapter 8 of the Superfund Method (Berman and Kolk 1997), as described briefly below. In addition, the ACM and soil fractions of these samples need to be separated.

Because individual pieces of ACM that are too large to pass through a 3/8th inch (1 cm) sieve may be present in these samples, it is important to be sure that such material is homogeneously divided among the initial halves of these samples, therefore the order with

which these samples are to be sieved, homogenized, and split varies from the procedure defined for standard samples. This alteration constitutes a "test" procedure that is to be evaluated during this part of this study.

In this procedure, samples are first to be homogenized in the manner described in Section 1.1.2 with the following modification. If a piece of ACM is found during homogenization that is too large to fit through the chutes of the riffle splitter, the piece is to be removed and held for inclusion in the ACM fraction that is later to be weighed.

Once homogenization is completed, the riffle splitter shall then be used to split the sample into two equal halves, which are each to be labeled. The first half is then to be sieved and split to create four equally-sized aliquots in the same manner described in Sections 1.1.1 and 1.1.3 for Standard Samples above. These aliquots are also to be labeled and stored in the identical manner described above for Standard Samples and specific instructions will be provided regarding their ultimate handling.

The second half of the sample that is generated as described above, is to be sieved while separating and isolating any apparent ACM (as described in Section 1.2.1 below). The fine fraction is then to be split (as described in Section 1.1.3) to generate four aliquots that are each to be labeled and stored as described in Section 1.1.3 and specific instructions will be provided regarding the ultimate handling of these aliquots.

1.2.1. Sample sieving with separation and isolation of ACM

IT IS IMPORTANT TO READ THIS SECTION IN ITS ENTIRETY PRIOR TO SIEVING THESE SAMPLES, AS THE PROCEDURE DIFFERS FROM THAT DESCRIBED FOR OTHER SAMPLES IN SECTION 1.1.1.

Prior to sieving, the mass of each sample shall be determined to the nearest 0.2 g. The sample shall then be sieved through a screen with $3/8^{th}$ inch (1 cm) openings.

Note that, because it is only the relative masses of the sample fractions that are important in this case, it is *NOT* necessary to adjust the moisture content (by drying) of these samples prior to determination of mass while conducting this procedure. As long as the entire procedure described here for sieving is completed expeditiously, changes in moisture content should not be important. At worst, they will be considered as potential process losses between the mass determination of the initial sample and the mass determination of the final coarse and fine fractions. At the same time, the sample should be kept sufficiently moist to prevent excessive dust generation during handling.

During sieving of these samples, begin by gently pouring the sample onto the sieve. Next, any material caught on the screen that appears to be ACM shall be removed from the

screen and placed in a pre-weighed bucket. After removing all visible material that appears to be ACM, be sure to manipulate the sample on the screen with gloved hands to maximize the amount of fine material that passes through the sieve. Any coarse material remaining on the sieve that can conclusively be identified as non-ACM shall also be weighed to the nearest 0.2 g. This latter material shall be disposed as asbestos-containing waste, once its mass is recorded.

Once all fine material has passed through the screen, gently spread the fine material out on a clean sheet of paper. Remove any additional (small) pieces of apparent ACM from the sample (which may have been sufficiently small to pass through the 3/8th-inch sieve). Add any such ACM to the pre-weighed bucket of ACM collected from the sieve screen. When this process is complete, quantitatively transfer the fine fraction of the sample to a pre-weighed bucket and determine the mass of the fine fraction to the nearest 0.2 g. Record all masses in an appropriate logbook along with any pertinent observations concerning the sample and/or any modifications required to this procedure. This fraction then needs to be split as described in Section 1.1.3.

Determine the mass of the ACM separated from the sample to the nearest 0.2 g. If the mass of the ACM that is isolated from the sample is less than 80 g, this material is then to be labeled as the ACM component of the sample from which it was isolated and the material shall be stored for possible analysis. If the mass of the ACM exceeds 80 g (which is very unlikely) the ACM sample shall be split (either using the riffle splitter) or by coning and quartering, until aliquots are obtained with masses that are smaller than 80 g. The observed masses of each such aliquot shall than be recorded and the aliquots shall be labeled and stored for possible analysis.

2. Initial Preparation for Samples Collected for Determination of Silt and Moisture Content

When requested of specific samples, two randomly selected sub-samples, each of an appropriate size, will be isolated from the requested sample, the first will then be analyzed for the determination of moisture content (ASTM D 2216-05) and the second will be analyzed for the determination of silt content (ASTM C 136-04).

If the size of the field sample is not sufficient to provide for separate components that can be analyzed for moisture and silt, respectively, a single aliquot will be collected and will first be analyzed for moisture content and second analyzed for silt content.


PBS

APPENDIX C:

STANDARD OPERATING PROCEDURES FOR EXTENDED ANALYSIS OF COMPOSITE SAMPLES TO PROVIDE AN IMPROVED UNDERSTANDING OF THE OCCURRENCE OF AMPHIBOLE

NORTH RIDGE ESTATES
KLAMATH FALLS, OREGON

ATTACHMENT 1 (TO P.O. 1023):
SOP'S FOR PREPARATION AND ANALYSIS OF SAMPLES
IN SUPPORT OF PHASE 1 OF THE RI/FS AT THE NORTH RIDGE ESTATES SITE,
KLAMATH FALLS, OREGON
D. Wayne Berman, Ph.D.
Aeolus, Inc.
February 25, 2005
The identity of the specific samples to be prepared and analyzed will be provided in separate, written authorization letters as the project proceeds. SOP's for each of the types of preparation and analyses that will be required are summarized below.

Sample Preparation

The following SOP's describe the preparation options that may be requested:

Pre-Preparation (Item No. 8 of Table 1 of the P.O.)

Samples received from the field (which may contain up to approximately 3 kg but will most likely be closer to 1 kg) will be weighed, dried, weighed, sieved through a sieve with 1 cm (3/8ths inch) openings (with any visible ACM cut/broken so that it is forced through the sieve), the coarse and fine fractions will be weighed, and (if required) the fine fraction will be homogenized and split to obtain samples of the appropriate mass for dust generation/elutriation per the Modified Elutriator Method (Berman and Kolk 2000). An aliquot will also be set aside for silt content analysis.

Elutriator Preparation (Item No. 1 of Table 1 of the P.O.)

Appropriately prepared samples will be stored in a humidity-controlled chamber for preconditioning.

Conditioned samples will then be placed in the tumbler of the dust generator/elutriator and a minimum of three filters will be prepared for mass determination of respirable dust and for determination of asbestos by transmission electron microscopy (TEM) analysis following preparation of grid specimens by direct transfer, all per the general procedures of the Modified Elutriator Method (Berman and Kolk 2000).

Sample Analysis

The following SOP's describe the analytical options that may be requested:

Routine Analysis (Item No. 2 of Table 1 of the P.O.)

Prepared samples will be analyzed by TEM for the determination of asbestos per the general procedures defined in the Modified Elutriator Method (Berman and Kolk 2000) with the adaptations described below.

Use the counting and identification rules specified in ISO 10312 for determining asbestos concentrations with the following modifications:

• count only structures that satisfy the dimensions of either protocol structures or PCME structures;
• determine the number of grid openings required to achieve an analytical PM10 sensitivity of 2x10 structures/g .. Define this number as "P." 6
• for each of the five specimen grids to be prepared from each sample filter, continue counting until one of the following obtains:
S complete the scan of the grid opening on which the 5 protocol structure th longer than 10 :m is detected; or
S scan a total of P/5 grid openings;
whichever comes first.

ISO Analysis (Item No. 3 of Table 1 of the P.O.)

Prepared samples will be analyzed by TEM in the same manner described for Routine Analysis (above) with the modification indicated below.

Two separate scans will be required. A scan at 10,000 x for all structures longer than
5 :m and a second scan at 20,000 x for all structures longer than 0.5 :m.
For the scan of structures longer than 5 :m:
Count all structures that satisfy ISO requirements
Determine the number of grid openings required to achieve an analytical PM10 sensitivity of 2 x 10 structures/g .. Define this number as "P." 6
For each of the five specimen grids to be prepared from each sample filter, continue counting until one of the following obtains:
S complete the scan of the grid opening on which the 5 protocol structure th longer than 10 :m is detected; or
S scan a total of P/5 grid openings;
whichever comes first.

Page 3 of 7
For the scan of structures longer than 0.5 :m
Count all structures that satisfy ISO requirements.
Determine the number of grid openings required to achieve an analytical PM10 sensitivity of 1 x 10 structures/g .. Define this number as "Q." 7
For each of the five specimen grids to be prepared from each sample filter, continue counting until one of the following obtains:
S complete the scan of the grid opening on which the 5 ISO structure is th detected; or
S scan a total of Q/5 grid openings;
whichever comes first.
Extended Analysis (Item No. 4 of Table 1 of the P.O.)
Prepared samples will be analyzed by TEM in the same manner described for Routine Analysis (above) with the modification indicated below.
Use the counting and identification rules specified in ISO 10312 for determining asbestos concentrations with the following modifications:
• count only structures that satisfy the dimensions of either protocol structures or

PCME structures;
• determine the number of grid openings required to achieve an analytical PM10 sensitivity of 7x10 structures/g .. Define this number as "P." 5
• for each of the five specimen grids to be prepared from each sample filter, continue counting until one of the following obtains:
S complete the scan of the grid opening on which the 5 AMPHIBOLE th protocol structure longer than 10 :m is detected; or
S scan a total of P/5 grid openings;
whichever comes first.
Note, if a sufficient number of intact grid openings is not available on any particular set
of grid specimens, than analysis is to proceed until one achieves an analytical sensitivity as close to the target as possible and a note indicating the problem is placed
on the raw count sheet.
Special Analysis (Item No. 5 of Table 1 of the P.O.)
This procedure applies only to samples that have been previously analyzed. The objective is to increase the total sensitivity of the analyses. Prepared samples will be

Page 4 of 7
analyzed by TEM in the same manner described for Routine Analysis (above) with the modification indicated below.
Use the counting and identification rules specified in ISO 10312 for determining asbestos concentrations with the following modifications:
• count only structures that satisfy the dimensions of either protocol structures or

PCME structures;
• determine the number of grid openings required to achieve an analytical PM10 sensitivity of 1x10 structures/g .. Define this number as "P." 6
• for each of the five specimen grids to be prepared from each sample filter,

continue counting until one of the following obtains:
S complete the scan of the grid opening on which the 5 AMPHIBOLE th
protocol structure longer than 10 :m is detected; or
S scan a total of P/5 grid openings;
whichever comes first.
Note, if a sufficient number of intact grid openings is not available on any particular set
of grid specimens, than analysis is to proceed until one achieves an analytical sensitivity as close to the target as possible and a note indicating the problem is placed
on the raw count sheet.
PLM-400 Analysis (Item No. 6 of Table 1 of the P.O.)
For this analysis, small sub-samples will be collected from samples prepared for TEM

analysis (as described above) and these will be mounted on slides and analyzed by Polarized Light Microscopy using the Point Count procedure and counting a total of 400
points. The SOP to be followed for PLM-400 analysis is Perkins and Harvey (1993).
PLM-1000 Analysis (Item No. 7 of Table 1 of the P.O.)
For this analysis, small sub-samples will be collected from samples prepared for TEM

analysis (as described above) and these will be mounted on slides and analyzed by Polarized Light Microscopy using the Point Count procedure and counting a total of 400
points. The SOP to be followed for PLM-1000 analysis is Perkins and Harvey (1993), but with the method modified to include counts of 1000 points rather than the traditional
400.

Silt Content Analysis (Item No. 10 of Table 1 of the P.O.)
Each aliquot selected for particle size determination shall first be weighed and then dry
sieved using a 200-mesh to determine the silt content. The mass of material passing the 200-mesh sieve shall then be weighed and the ratio of the mass of material passing
through the 200-mesh sieve to the total mass of the original material shall be reported
as the silt content. Silt content is to be determined per ASTM Test Method C136-04.
Note that 300 g of material are required for silt content analysis.
Moisture Content Analysis (Item No. 11 of Table 1 of the P.O.)
For a separate set of samples to be provided from the field, such samples will be analyzed for the determination of moisture content per ASTM Test Method D2216-98.
Note, ff there is gypsum in the soil the Test Method states that the recommended drying
temperature of 110 C may dehydrate the gypsum. The summary of the method states that an alternated drying temperature of 60 C can be used but the test report must state
that the moisture was not measured at the standard drying temperature. Thus, it will be
important to determine whether there is plaster in the field samples collected for this
analysis.
Reporting Requirements
Excel Reporting (No. 9 of Table 1 of the P.O.)
For samples to be analyzed by TEM, in addition to the raw count sheets, a summary lab
report is to be provided in electronic format as an excel worksheet. A proposed format
for the worksheet is provided as Exhibit 1. Modifications to this format will be considered subject to discussion and approval.
QC Requirements
The following types of QC analyses will be required to be completed along with the

project samples to be defined in a followup authorization letter. The required frequency
of these samples are indicated.
! lott blanks. Two filters shall be collected at random from each lott of filters and
shall be analyzed prior to use of filters from each respective lott. Note that, through careful planning, some of the same filters representing lott blanks can also be used for sand blanks.
! laboratory blanks. Periodic analyses of laboratory air is assumed to be conducted as part of EMS Laboratory's routine, internal QC program. Records

for results from the blanks sampled during the period of this project shall be included as part of the reporting for this project.
! Sand blanks. A sand blank shall be collected, run on the elutriator, and analyzed prior to initiating project sample runs. These samples shall be collected in the elutriator for a sufficient period of time combined with scanning of
a sufficient number of grid openings to assure that an equivalent analytical PM10 sensitivity of 7x10 s/g is achieved. Sand blanks shall then be run after 5 every six project samples and shall be stored in case they are needed to design corrective actions. Unless project samples containing substantial numbers of structures are observed during the project, it will only be necessary to analyze additional sand blanks at a rate of one per every 24 project samples. These samples will be tracked and invoiced as regular project samples.
! duplicate splits and replicate counts. A schedule of duplicate splits and replicate counts (for various types of analyses, including those for TEM, PLM, silt content, and moisture content) will be defined in various authorization letters, as the project proceeds. Although these samples will need to be prepared in the laboratory, they are to be presented to the analysts blind. They will be tracked and invoiced as regular project samples.
References
Berman, D.W. and Kolk, A.J. Draft: Modified Elutriator Method for the Determination of
Asbestos in Soils and Bulk Materials, Revision 1. Submitted to the U.S. Environmental
Protection Agency, Region 8. May 23, 2000.
Berman, D.W. and Kolk, A.J. "Superfund Method for the Determination of Asbestos in Soils and Bulk Materials." Prepared for the Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency. EPA 540-R-97-028. 1997.
Perkins, RL; Harvey, BW; Test Method: Method for the Determination of Asbestos in Bulk Building Materials. EPA/600/R-93/116. July, 1993.

EXHIBIT 1:


PBS

APPENDIX D:

STANDARD OPERATING PROCEDURE FOR EVALUATING COPCs OTHER THAN ASBESTOS

NORTH RIDGE ESTATES
KLAMATH FALLS, OREGON

Appendix D
SOP for Evaluating COPCs Other Than Asbestos
North Ridge Estates, Klamath Falls, Oregon

STANDARD OPERATING PROCEDURE FOR EVALUATING COPCs OTHER THAN ASBESTOS AT THE NORTH RIDGE ESTATES SITE, KLAMATH FALLS, OREGON

Dulcy A. Berri, RG
PBS Engineering and Environmental
July 7, 2005

Based on the historical usage of the Site and vicinity as a marine military barracks and subsequent technical school, the chance that Contaminants of Potential Concern (COPCs) other than asbestos may be present in site soils needs to be considered. Potential source areas will be identified through thorough compilation of historical documents and records. Preliminary areas of concern and COPCs identified in the draft RI/FS Work Plan (Berman and Berri 2005) include:

- Lead from lead-based paint on buildings; automotive shops, gunsmithing, firing range operated by OTI;
- Polychlorinated biphenyls (PCBs) from electrical transformers known to have been historically present at the site;
- Gasoline, diesel, waste oil, and/or petroleum-based solvents from a service station that may have operated at the site, as well as OTI automotive workshops;
- Perchloroethene (Perc) from a dry cleaning facility that may have been operated within the laundry known to have operated at the site;
- Various organic solvents from the automotive, paint, and other mechanical shops that operated at the site; and
- Medical wastes from the reported disposal of wastes that may have been generated during operation of the various medical facilities known to have operated at the site both by the Marines and by OTI.

This SOP describes the detailed procedures to be used to characterize source areas by surface and subsurface sampling and analysis of soil and potentially other methods of investigation. Groundwater is not expected to be a media of initial concern, and is not expected to be encountered in the course of this study. If a source area is identified, further evaluation specific to those findings would be designed and conducted.

Appendix D
SOP for Evaluating COPCs Other Than Asbestos
North Ridge Estates, Klamath Falls, Oregon

1. Sampling Design

Based on a thorough review of documents pertaining to historical activities, site locations will be identified that have a potential for the presence of surface or subsurface contaminants other than asbestos. Those locations will be overlaid on a map depicting the current layout and structures at the site, and specific locations for sample collection will be identified on the resulting base map.

The full range of potential chemical contaminants will be listed for each location, and target sampling depths determined based on the nature of the concern, e.g. if a release would have been surficial (e.g. containerized chemicals) or subsurface (e.g. underground storage tanks). Knowledge of characteristic fate and transport will also be considered (e.g. volatile organic chemicals are unlikely to remain at substantial concentrations at the surface but may have migrated downward).

Sample locations will be selected to minimize the chance of missing COPCs that may be present, therefore placed in those locations where COPCs are deemed most likely to be present at the highest concentrations, based on available information. Samples will be distributed areally and vertically and in sufficient numbers to maximize the likelihood of detecting COPCs, if present. At least two discrete soil samples will be collected from any area of potential concern.

Samples will be tested for the full range of COPCs that may be present at each location, at laboratory detection limits sufficient to detect COPCs at levels that may affect human health.

Appropriate sample volumes, sample containers, and sample collection protocols will be determined depending on the nature of the COPCs to be investigated. Refer to the table in Section 11 for COPCs that have preliminarily been identified. If COPCs are added as a result of the historical document review, that are not included in this SOP, specific methods for sampling and analysis will be obtained from EPA SW-846 or equivalent, and incorporated into the Sampling Design.

2. Preparation for Sampling

The current Health and Safety Plan for North Ridge Estates will be reviewed and followed at all times. In addition, potential health and safety concerns related to the COPCs under investigation will be compiled and will include field screening methods for the potential levels of such COPCs that may present a health risk. This information will be reviewed by all field personnel including subcontractors.

Appropriate sampling equipment and supplies will be assembled, inspected to assure proper working condition, calibration if necessary, and cleanliness. If subcontractors are to be utilized, this SOP will be reviewed with them prior to start of work.

Appropriate verification of access to sampling locations will be made to assure that work activities, date and time are acceptable to property owners. A request for a public utility locator service will be made if sampling is to conducted at depths greater than 1 foot. Clearance by a private utility locator should be considered in addition to the public locator service.

3. Sample Collection

This section presents general sample collection and identification procedures to be used for all soil sampling, as well as special procedures for sampling certain specific COPCs.

3.1 General Procedures

All soil samples will be collected using a clean pair of disposable gloves. Each sample will be placed directly into a clean sampling jar provided by the laboratory. Sample containers will be filled completely and the threads will be cleaned to the extent practical prior to sealing the lid, in order to prevent potential contaminant migration to or from the samples. The container will be properly labeled, then placed into a storage cooler.

Sample locations will be noted on a site plan, measured with GPS equipment and measured with a cloth tape to the nearest site feature. Locations from which each sample is collected will be recorded in the field logbook.

3.2 Sample Identification

Each sample to be shipped for laboratory analysis will be labeled with a unique number that will include the sample site identification number, an indication of the type of sample, an indication as to whether the sample is an original sample or a duplicate, and the date that the sample is collected. It is thus suggested that sample numbers be constructed with 9 digits as follows:

QQ-Y-mm-dd-yy

where:

-QQ is the two-digit code indicating the sampling site from which the sample was collected;
-Y is either a 0 or a 1 indicating whether the sample is a project sample or a duplicate, respectively;

-the last set of digits represents the date in standard format.

3.3 Collection of Samples for Volatile Organic Compounds Analysis

It is of utmost importance to minimize sample agitation and aeration when collecting samples for analysis of VOCs, in order to minimize loss of volatile compounds from the sample. If collecting sample material for this and other types of analyses, collect the sample for VOCs analysis first.

Upon collection of the sample, sample containers will be quickly filled, compacting soil material and filling completely to prevent headspace inside the container. The container threads will be cleaned and the lid sealed promptly, then the container exterior cleaned. The container label will be inspected for completeness, then the container stored in a cooler.

3.4 Collection of Samples for Non-Volatile Organic Compounds or Inorganic Compounds Analysis

Sample material adequate to fill sample containers will be placed into a clean stainless steel bowl and homogenized.. Containers will then be filled by compacting and filling completely, then wiping the container threads and sealing the lid securely. The container label should be inspected, then the container stored in a cooler.

3.5 Field Screening Methods

As a supplement to soil sample analysis, and following collection of the sample into containers, remaining soil from the immediate sample vicinity will be screened in the field and observations records in the field logbook. Such screening will include careful visual observation of unusual color, texture or moisture; notation of obvious olfactory indications (DO NOT EVER examine or smell soils close to the face).

Potential presence of oil COPCs will be evaluated by placing a small amount of soil in a bowl and swirling with potable water; presence of a sheen on the water surface suggests non-aqueous-phase liquids of potential concern may be present.

Screening for potential VOCs and semi-volatile compounds will be performed with a photoionization detector (PID), as follows. Place ¼ to ½ cup of soil in a Ziploc bag, seal the bag, break up the soil, and let sit for one minute or so (longer in cold weather). Place the end of the PID probe into the bag (through a small opening in the "zipper") and record reading after 5-7 seconds. The PID may malfunction in wet, humid, or rainy conditions. A true detection of

volatile organic compounds should quickly spike the readout to a certain level and then fluctuate around that value. Record the average maximum value.

4. Sample Preservation

Soil sampling and analysis for COPCs preliminarily identified and presented in this SOP does not require the use of preservatives in sample containers nor requires that sample media be treated in the field.

Samples will be stored in coolers at approximately 4 degree Celsius until delivery to the laboratory.

5. Field Documentation

Documentation. The following information will be recorded in the field logbook for each sample collected:

-the sample identifier: sample ID number (Section 3.2), sample depth, and the date that the sample was collected;

-the time that the sample was collected, general weather observations;

-characteristics important to the interpretation of laboratory findings will be noted, such as relative soil moisture, soil color and type, presence of odors or discoloration, presence of construction debris, type of ACM that is present, etc.

-the GPS location of the sample;

-any required modifications to the location initially selected for sample collection along with the reasons (i.e. the nature of any field obstructions) for needing such modification;

-any changes or modifications required to the above-indicated procedures for sample collection;

-any other, potentially relevant information concerning the conditions under which the sample is collected (e.g. any required weights or similar information).

6. Sample Custody, Packaging and Shipping

The Chain-of-Custody (COC) protocol begins with sample collection and ends with sample disposal, and creates a document for each sample during this time frame; under no circumstances is there to be a break in custody. A COC form will be completed by staff for each sample collected, and will remain with the samples until receipt in the laboratory.

Samples will be bubble-wrapped as needed to prevent breakage, and maintained under chain-of-custody by the PM or other sampling personnel until shipped or

hand-delivered to the laboratory. It is anticipated that samples will be shipped on a daily basis. The PM will coordinate with the analytical laboratory in order to assure that all sample shipments are received by laboratory personnel in an appropriate time frame, and to minimize sample transport and holding time.

7. Decontamination of Equipment

All non-dedicated equipment used to collect samples (e.g. trowels, augers, shovels, heavy equipment samplers) will be decontaminated before coming into contact with any sample.

Equipment will be decontaminated by washing with low-phosphate detergent, rinsing with potable water then rinsed with distilled water, and allowed to air dry. Sampling equipment will be similarly decontaminated prior to removing it from the site. Heavy equipment should be decontaminated with a hot water pressurized spray, scrubbed and visually inspected then allowed to air dry.

Equipment that may have come into contact with oil will be cleaned with detergent, rinsed with distilled water then rinsed with methanol.

Decontamination wastewater will be securely held in labeled containers until sampling results are obtained and proper disposition of the waste can be determined.

8. Investigation-Derived Wastes

Excess soil material generated during sampling, and decontamination liquid and solids will be stored in sealed, labeled containers in a secure storage location (potentially the Warehouse) pending the results of sample analyses, and evaluation for proper disposal of the materials.

9. Site Restoration

Disturbance to ground surfaces will be restored to the extent that is reasonably feasible. If soil samples are collected in unpaved areas, the sample site will be backfilled by hand or equipment, even with surrounding soil. Deeper sample holes created by sampling rigs may be backfilled with bentonite.

If samples are collected through concrete or asphalt surfaces, the hole will be filled with soil and the surfacing material restored with quick-set concrete.

Use of sampling equipment will strive to minimize impacts to the surrounding areas, and whenever feasible, be conducted off-pavement and away from

landscaping/lawn areas. No other restoration is anticipated, beyond generally smoothing disturbed surfaces.

10. Quality Control/Quality Assurance

Duplicate soil samples will be collected at a rate of 10% of total daily samples, with at least one duplicate per analytical method to be performed. Duplicate samples will be blind-labeled and submitted to the laboratory as routine project samples.

On a daily basis, one equipment decontamination rinsate blank will be collected to determine if decontamination procedures are adequately removing COPCs between each sample collection event. The rinsate blank will be tested for each of the COPCs under evaluation over the course of that day.

11. Sample Containers, Sample Hold Time, Laboratory Analyses

COPC:	Laboratory Analysis Method Name:	Soil Sample Container Size:	Holding Time:
Petroleum Hydrocarbons	Northwest Methods:		
Identification	NWTPH-HCID	8 oz	7 days
Gas-Fraction	NWTPH-Gx	8 oz	14 days
Diesel-Heavy Oil Fraction	NWTPH-Dx	8 oz	14 days
Polynuclear Aromatic Hydrocarbons (PAHs)	EPA Method 8270D	8 oz	14 days
Polychlorinated Biphenyl Compounds (PCBs)	EPA Method 8082A	8 oz	14 days
Heavy Metals – RCRA 8			
Total Metals	EPA Methods 6010/7000	8 oz	6 mos.
Leachable (TCLP) Metals	EPA Methods 1311/6010/7000	8 oz	6 mos.
Volatile Organic Compounds (VOCs)	EPA Method 8260B	8 oz	7 days (unpreserved)